HIGH-TECH VEGETABLE CULTIVATION

Edited by

PROF. ASHIM CHOWDHURY

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HIGH-TECH
VEGETABLE CULTIVATION

79

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Prof. Ashim Chowdhury

CENTRE FOR TESTING AND TRAINING FOR PROVIDING TECHNICAL BACKUP TO THE BENEFICIARIES FOR AGRICULTURAL AND HORTICULTURAL DEVELOPMENT

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Date : August 06, 2015

MESSAGE

It is a great pleasure for me to introduce the "Manual for *High Tech Vegetable Cultivation*" going to be published by the Calcutta University Press, University of Calcutta. It is basically the outcome of the training & workshop duly organized by the "Center for Testing & Training for providing Technical back up to the beneficiaries of Agriculture & Horticulture Development", Institute of Agricultural Sciences, University of Calcutta held on 21-22 January 2012, for the benefits of lower level beneficiaries to develop Horticulture in West Bengal.

I am appreciating the effort of Prof. Ashim Chowdhury for his initiative of publishing the outcome of the training & workshop by the center of University of Calcutta by means of which lower level beneficiary would be immensely benefitted. The training programme was organized by the Centre in collaboration with F P I & Horticulture Department, Government of West Bengal, Centre for Strategic Studies, Salt Lake, Kolkata, Seed & Input Industries.

(Sugata Marjit)

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MESSAGE

I am glad to know that a Technical Maual for **High Tech vegetable cultivation** is going to be published by the University of Calcutta Syndicate approved **"Center for Testing & Training for providing Technical back up to the beneficiaries of Agriculture & Horticulture Development"**, Institute of Agriculture Science, F/Ag. This manual is compilation of the lectures by the resource persons from different Universities, Research Institutes delivered during the training programme held on **"High Tech. Vegetable cultivation for uniform economic return"** in collaboration with Centre for strategic studies, saltlake, Kolkata, seed & Input Industries, **on 21-22 January 2012** for the benefits of lower level beneficiaries for the development of Horticulture in West Bengal. Prof. Suranjan Das, Vice-chancellor, Calcutta University was kind enough to inaugurate the programme and Prof. M. G. Som, Former vice-chancellor-BCKV was also present as chief guest. Lower level beneficiaries from different districts participated in this training programme. This manual would be of great help for the participants.

I wish that this type of training programme on vegetable cultivation & various other important issues on Horticulture would be organized by the Center, University of Calcutta in future.

(Prof. A. K. Dolui)

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MESSAGE

It is great pleasure for me that a manual for **High Tech vegetable cultivation** is going to be published by "Center for Testing & Training for providing Technical back up to the beneficiaries of Agriculture & Hoticulture Development", Institute of Agricultural Science, Calcutta University. This manual is a compliation of the lectures delivered by experts from different Universities, Research Institutes, during the training programme on **"High Tech. Vegetable cultivation for uniform econimic return"** organized by the centre in collaboration with F P I & Horticulture Department, Govt. of W.B., Centre for strategic studies, saltlake, Kolkata, seed & Input Industries, held **on 21-22 January 2012** for the benefits of lower level beneficiaries to develop Horticulture in West Bengal.

I hope the publication would help immensely the growers involved in production of horticultural crops in West Bengal and India as a whole.

Tapash Dasgupta
(Prof. Tapash Dasgupta)

PROF. A. K. MANDAL
Director

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MESSAGE

I am glad to know that a Technical Manual for **High Tech vegetable cultivation** is going to be published by the University of Calcutta Syndicate approved **"Center for Testing & Training for providing Technical back up to the beneficiaries of Agriculture & Horticulture Development"**, Institute of Agricultural Science, F/Ag. This manual is compilation of the lectures by the resource persons from different Universities, Research Institutes delivered during the training programme held on **"High Tech. Vegetable Cultivation For Uniform Economic Return"** in collaboration with Centre for Strategic Studies, Salt Lake, Kolkata, Seed & Input Industries, **on 21-22 January 2012** for the benefits oflower level beneficiaries for the development of Horticulture in West Bengal to be printed by the University of Calcutta, Press. **Prof. Suranjan Das, Vice-Chancellor, University of Calcutta was kind enough to** inaugurate the **programme and Prof. M.G. Som, Former Vice-Chancellor-B.C.K.V.** was also present as **chief guest.** Lower level beneficiaries from different districts participated in this training programme for the benefits of vegetable production. This manual would be of great help for the participants.

I wish that this type of training programme on vegetable cultivation and various other important issues on Horticulture would be organized by the Center, University of Calcutta in future.

10.8.15
(Prof. A. K. Mandal)
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From the Desk of the Editor

I am very glad to introduce the Manual on High-tech Vegetable cultivation compiling and editing the Lectures of the Resource persons from different Universities, Research Institutes delivered during the Training programme on various issues of High-Tech Floriculture for the benefits of officers and lower level beneficiaries for the Development of Horticulture in West Bengal & Tripura. The Training programme was organized by the Syndicate approved "Center for Testing & Training Development", Institute of Agricultural Science, University of Calcutta on ***"High Tech. Vegetable cultivation for uniform economic return"*** in collaboration with F P I & Horticulture Department. Govt of W.B., Centre for strategic studies, salt lake, Kolkata, seed & Input Industries, **on 21-22 january 2012.** Growers & retailers, of our state actively participated in the programme along with representatives from Corporate, University & Institutions. The Technical resource persons from allover the country delivered talks in the relevant field especially on Cropping system, Crop Improvement & seed, management viz; soil, pest, Irrigation, marketing, seed, nanotechnology, Biotechnology etc. About 200 participant form West Bengal were participated in this workshop-training programme.

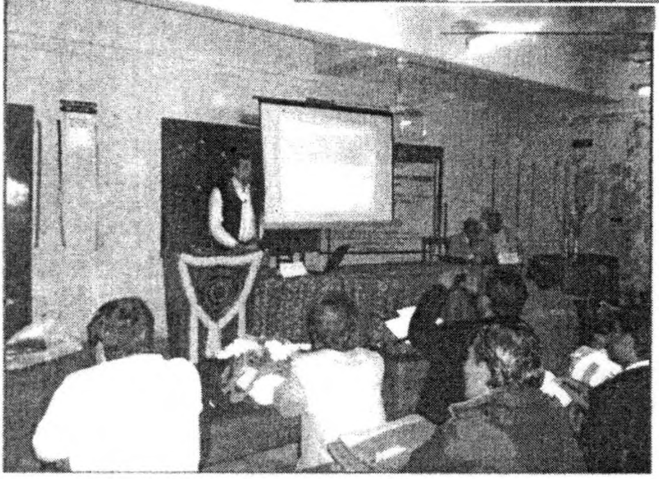
Resources persons on various important topics from different Universities, Research Institutes delivered their lectures to the participants from allover the state & also from this University. The manual is consisting of technical matter on High-tech Vegetable cultivation in west Bengal viz; Status, Fertilizer management, Weed management, Insect & disease management, protected cultivation etc.

In my opinion this type of technical training manual will be of great help for the participants from West Bengal & they will in turn transfer the technical information to the lower level beneficiaries in respect of various problems. The "Center for Testing & Training Development", Institute of Agricultural Science, University of Calcutta wish to continue this effort on various other topics in collaboration with other organizations under the leadership of In-charge, Institute of Agricultural Science.

(Ashim Chowdhury)
Editor& In-charge
"Center for Testing & Training..........Agri/Horti Development"

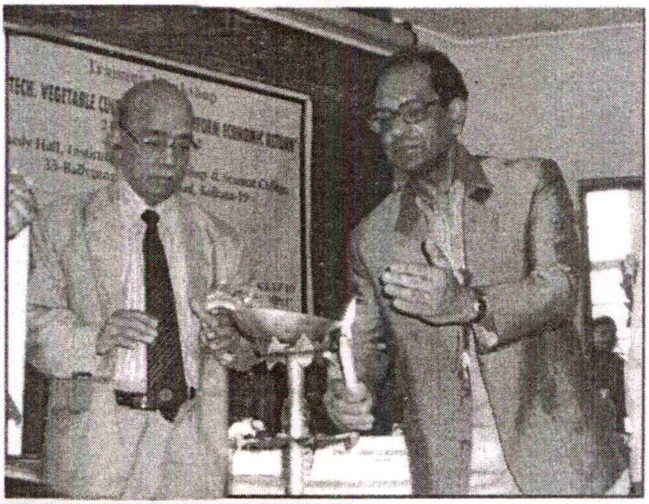
HIGH TECH. VEGETABLE CULTIVATION FOR UNIFORM ECONOMIC
21-22 January 2012
at
Kennedy Hall, Institute of Jute Technology
Ballygunge Circular Road, K
Organised by

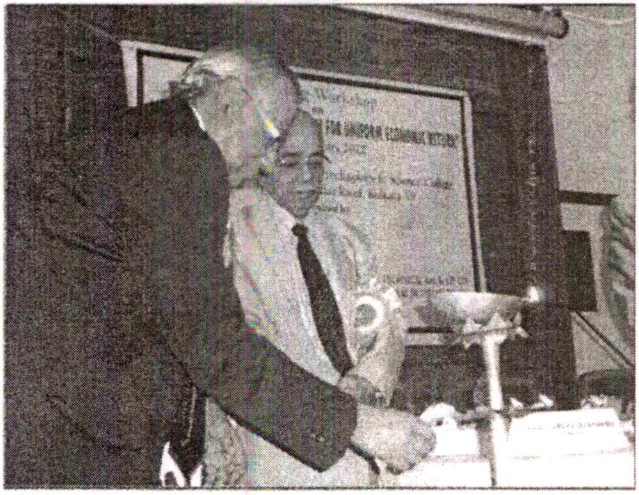
Release of Technical
manual on High-Tech
Floriculture. (right to left,
Prof. Suranjan Das,
VC, CU; Prof. M.G. Som
& Prof. Ashim Chowdhury)



Participants in the
workshop (above)
Prof. J. Tarafdar of BCKV
delivering lectures in
technical session (left)

Chief guests at the workshop
Prof. Ashim Chowdhury,
Prof. M.G. Som, Prof. Suranjan
Das, and Prof. A. K. Dolui
(left to right)





Inauguration of the workshop
by Vice-Chancellor,
University of Calcutta and by
Vice-Chancellor, BCKV
(above) and by
Incharge,
Centre for testing &
training...development (below).

CONTENTS

Page

Status of vegetable crops in West Bengal 1
— *M. G. Som and P. Hazra*

A hand on management practices for Vegetable Cultivation and their Economic profitability for Betterment of Livelihood for Lower level beneficiaries. 12
— *Soumen Bose, Kamal Kanti Sen and Ashim Chowdhury*

Integrated nutrient management in vegetable crops 24
— *Niharendu Saha and Biswapati Mandal*

Protected cultivation of Capsicum (*Capsicum annum L*) 35
— *T. K. Chowdhuri and S. Das*

Protected and precision vegetable farming in the plains of West Bengal 38
— *P. Hazra and M. K. Samanta*

Genetic Improvement of Crop Plants 45
— *Subhankar Roy Barman*

Important diseases of Vegetable Crops and their Management with biorational agrochemicals 55
— *S. Saha, M.Loganathan, A.B.Rai and R. Garg*

Vegetable Mite Management With Recent Acaricides 61
— *P. K. Sarkar*

Weed management in vegetable crops 73
— *B. Duary, M.K.Bhowmick, A. Chowdhury*

Vegetable Disease management with Biorational pest control agents 83
— *Jayanta Tarafdar*

Pesticides Residue Management in Vegetable crops 92
— *Saswati Pradhan, Ujjal Kumar Pati, Sambit Datta, Ashim Chowdhury, Sankhajit Roy*

Manual For Potato Clean Seed Production 97
— *Subirkumar Bardhanroy*

Seed invigoration for improved field performances with reference to vegetable crops 102
— *P. Guha and A. K. Mandal*

Phytochemicals In Integrated Pest Management For Vegetables 111
— *Ujjal Kumar Pati, Sambit Datta, Dr. Ashim Chowdhury*

Potato Cultivation Through T.P.S (True Potato Seed) - A Revolution 115
— *Pinaki Acharyya, Uttam Saha*

Nanotechnology - our mantra of present and future in agriculture and food 121
— *Savitri Chakraborty & Ashim Chowdhury*

Paschimbange sabji utpadaner chalchitra o porikalpana 130
— *M. G. Som and P. Hazra*

"Surokhito o sukkah nirdeshi" projuktir madhyame uccha gunomaner o asamayer sabji utpadan 138
— *P. Hazra, Arup Chattopadhyay, Malay Kumar Samanta*

Sabji chaser somvabona o samasya 152
— *T. k. Maity*

Molecular Techniques For Genetic Purity Analysis With Special Reference To Vegetable Seed. 157
— *Ashim Chowdhury, Sambit Datta And Ujjal Kumar Pati*

Potentiality and Prospect of Vegetable Crops – An Overview 165
— *P. K. Chattopadhyay*

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STATUS OF VEGETABLE CROPS IN WEST BENGAL

M. G. Som and P. Hazra

Vegetables, the most suitable alternative to provide nutritional security : The scenario of burgeoning population and meagre average intake of vegetables in the country as a whole particularly in the rural sector speaks of the increasing pressure on food grains. It is very difficult to cope up with the rising demand of food grains and at the same time, overwhelming dependency on food grains caused rampant malnutrition, the very feature of India. According to the Social Development Report recently released by the Council for Social Development, 260 million Indians live below poverty line of which 193 million are in rural India. Hunger in its different manifestations i.e., undernourishment, malnourishment or starvation is the biggest killer of all. Millions remain hungry even today because of poverty, lopsided distribution of wealth and food and faulty consumption patterns with more than 221 million of its population undernourished, India beats sub-Saharan Africa's 203.5 million and China comes third with 142.1 million undernourished population. India also tops with 2 million children who die every year due to serious malnutrition and highest number of anaemic woman. Since the geography of hunger has a direct bearing on the geography of disease, it is important to take into account the fact that availability of nutrition food has a dramatic effect on disease incidence. According to the studies of Indian Council of Medical Research, New Delhi and National Institute of Nutrition, Hyderabad, meagre intake of vegetables, the low cost protective foods, is largely responsible for malnutrition among the majority of our population (**1**).

The value of vegetables goes beyond the provision of necessary vitamins, minerals, micronutrients and in a number of cases, protein. Vegetables are particularly important source of micro-nutrients viz. calcium, phosphorus, iron and magnesium vitamins especially provitamin A, vitamin C, vitamin B2, thiamine and folic acid and dietary fibre. About 90% of human dietary vitamin C and 50%of vitamin A requirement is fulfilled from fruits and vegetables. Although, vegetables do not contain an active vitamin A, they are rich source of provitamin A (ß carotene), which are readily converted into active retinol (vitamin A) in the liver and intestine. Despite lycopene of tomato and tomato-based food products having no provitamine A activity, this specially unsaturated carotenoid presents very particular health benefits through its powerful antioxidant properties. In addition, vegetables also supply fair amount of carbohydrates, proteins (7%) and calories (10%). Dietary factors that enhance non-haem iron absorption include ascorbic acid, meat, poultry, fish and other seafood and low pH namely lactic acid and in south Asia including India where meat intake is low , ascorbic acid (vitamin C) emerges as one of the most important enhancers of iron absorption. Diets rich in vegetables are associated with various positive outcomes such as reduced incidence of lung cancer, beneficial effects for kidney function reduce coronary artery disease, diabetes and several cancers, slow down age-related declines in brain function and in cognitive and motor performance. Intake of different phytochemicals (mainly carotenoids, tocopherol, ascorbic acid, flavonoids, etc.) present in different vegetables have been implicated as protective factors against a wide variety human cancers, cardiovascular disease, age-related muscular degeneration and even HIV infections (2).

World Scenario of vegetables

India accounts for 11.5% share in the world's total vegetable production and is second only to China. The growing popularity of vegetarian diet and the rising awareness of consumers about the importance of vegetables in a balanced diet have opened up the market for this horticulture item both in the domestic front and globally. The total world trade for fresh vegetables is of the tune of 9.0 billion $. The largest importer is the United States accounting for 21% of the total world imports followed by Germany with 18% share. The other importing countries are UK (10%), France (8%), Canada (6%) and Japan (5%). Netherlands, Mexico and Spain are the largest exporters of vegetables in the world. Surprisingly, both China and India's share in the world exports is insignificant.

The most widely traded vegetable is tomato accounting for 36% share in the world trade, followed by chillies and onions. Other vegetables having substantial share are gherkins and cabbage. Some of the non-traditional vegetables that are widely traded, especially in European and South East Asian countries are asparagus, celery, baby corn, Brussels sprout, broccoli and cherry tomato. Among the processed vegetables that are traded, preserved gherkins and dehydrated onions and peas are most important. Sri Lanka and Bangladesh have been the major importers. Major export destinations from India are UAE, Sri Lanka, Bangladesh, Egypt and Malayasia (3).

Demand of vegetables in India

According to the India Development Report of Food and Nutrition, 2002 the consumption of wheat and rice in human diet in India has declined sharply even in rural areas and it will decrease further. Growth in vegetable production in India should keep pace with the rising demand for the burgeoning population which is expected to be about 1.20 billion in the year 2020 and 1.52 billion in 2050. The increase in urban population will result in more consumption of vegetables The Indian people over the next two decades, by the year 2020 would move towards other products, with the higher percentage growth, such as milk and milk products (159%), fruits and vegetables (134%) and meat and fish (131%) in comparison to all cereal consumption (52%). The consumption of fruits and vegetables is expected to be 113.17 million tonnes by 2020.

Table 1. Demand for vegetables in India (million tonnes)

Year 2015		Year 2030	
LIG	HIG	LIG	HIG
123.82	151.86	150.82	193.56

LIG: Low income growth, HIG: High income growth

Table 2. Percentage growth in consumption of cereals and non-cereal products

Product	Year		Percentage growth
	2000 (m. tonnes)	2020 (m. tonnes)	
Milk and Milk Products	64.15	165.84	159
Fruit and Vegetables	48.45	113.17	134
Meat and Fish	4.67	10.80	131
All Cereals	145.07	221.1	52

Scenario of vegetable farming in West Bengal

West Bengal is the leader in the country and accounts for 19% of the country's production of vegetables. Present production of vegetables excluding potato in West Bengal is 137.22 lakh tones from 9.54 lakh hectares and that including potato is 232.17 lakh tones from 13.54 lakh hectares (Department of FPI and Horticulture, Department of Agriculture, Govt. of West Bengal, 2012). Productivity of vegetable crops in the state both excluding potato (14.38 t/ha) and including potato (18.19 t/ha) is much higher than the National average and within top five states with respect to productivity. Annual growth rate in production of vegetable crops in West Bengal is 2.6 % which is much higher than the National average. The State's unique location in the heart of the Gangetic delta and being bestowed with six agro climatic zones gives it a natural advantage in agriculture and horticulture. A pool of progressive farmers and small farm holdings are the added features that have brought the State to the forefront in production of a number of vegetable crops. Small and marginal farmers of West Bengal which account for about 95% of the total has long been taken vegetable farming as one of the prime livelihood option in the rural areas. Vegetables excluding potato and including potato occupies 10 and 14 percent of the cultivable area in the state as against the National average of hardly 3.0 percent.

Going beyond subsistence production, vegetable production had proved to be an economic activity that can be pursued by resource poorhouse holds without high capital investment in areas surrounding cities and sometimes within city boundaries. Vegetable farming provide continuous source of cash particularly to the small and marginal farmers, thus contribute to alleviating of poverty and contrasting the now progressing uncontrolled urbanization. In India, per capita land resources are limited (0.12 ha) which will further be decreased due to tremendous growth of population.

Total population in West Bengal on 01.10.05 was 8.53 crore which is expected to be 9.12 crore and 10.71 crore by 2011-12 and 2019-20, respectively with 1.4 % annual growth rate. Population of the Kolkata urban agglomeration will shot up from the present 2.24 crore to 3.48 crore and by 2011-12 and 2019-20, respectively due to rapid and sprawling urbanization and very high growth in urban economy compared to that in the rural sector. This high population per unit area of land in West Bengal coupled with rapid urbanization will significantly increase the demand of not only total but also wide array of vegetables particularly in the urban sector.

Agri Export Zone for vegetables in West Bengal

The concept of Agri Export Zone was introduced in the EXIM Policy of 2001-02. The aim was to promote exports of specific agro-products grown in a contiguous area of a particular Zone. The strategy is to adopt an end-to-end approach of integrating the entire value chain from farm to fork. The emphasis is on convergence of all existing schemes and incentives of Central and State Government agencies in a focused manner at every stage starting from procurement of raw materials to placing finished products on the shelf. The benefits that are anticipated from such a programme include better prices for agri-produce, improvement in product quality, boost in exports and increased employment opportunities.

As stated earlier, West Bengal is the highest producer of vegetables in the country. Diverse agro-climatic regions, wide variety of soils supplemented with substantial rainfall has made the State a forerunner in this sector. The state is the leading producer of brinjal (24.13%), cabbage (26.26%), cauliflower (26.34%) and okra (14.70%).

To leverage these advantages and to augment the returns to the farming community an Agri Export Zone was sanctioned for vegetables covering the districts of North 24-Parganas, Nadia and Murshidabad. This covers a major part of the Gangetic alluvium with high cropping intensity resulting in round the year availability for a number of vegetable crops. West Bengal has large marketable surplus in traditional vegetables like brinjal, cabbage, cauliflower, okra. The other vegetables popularly grown are peas, tomato and green chillies. Farmers have also started experimenting with exotic varieties like gherkin, baby corn, cherry tomato, brocolli and capsicum. The three districts under the Zone have a huge concentration of vegetable growers, especially in certain blocks close to Barasat. To make use of the dual advantages of raw material availability as well as having a huge urban market of Kolkata metropolis nearby, two processing units has been set up near Barasat. A perishable goods cargo complex has come up at Kolkata Airport as a part of infrastructure development for the Agri-Export Zones. The

Government is also planning to set up a modern grading –sorting-collection centre cum Terminal Market near Barasat to reduce the immense wastage that takes place on account of inefficient post harvest handling. At present more than 55 multipurpose cold storages are being operative in the state dealing with a number of vegetables.

Table 3. Size of land holdings in West Bengal

Size class (in ha.)	Operational Holdings	Operated Areas
Below 1.0	5462089 (80.4)	2758843(49.7)
1.0-2.0	1009328(14.9)	1606686(29.1)
2.0-4.0	282992(4.2)	783773(14.1)
4.0-10.0	34797(0.5)	178298(3.2)
10.0 & above	785(N)	218976(3.9)
All sizes	6789991(100.0)	5546576(100.0)

Source: Agricultural Census West Bengal-2000-01, Land and Land Reforms Department & Department of Agriculture, Government of West Bengal

Table 4. Area, production and productivity of vegetable crops in West Bengal in 2011-12

Name of district	Area ('000 ha)	Production ('000 t)	Productivity (t/ha)
Darjeeling	22.03	241.24	10.95
Jalpaiguri	53.35	866.35	16.23
Coochbehar	54.06	950.72	17.58
Uttar Dinajpur	35.75	482.16	13.48
Dakshin Dinajpur	46.37	577.72	12.45
Malda	57.49	735.59	12.79
Murshidabad	86.69	1447.58	16.69
Nadia	84.11	1301.87	15.47
24 Parganas (North)	71.15	1076.07	15.12
24 Parganas (South)	74.55	1053.53	14.13
Howrah	14.34	180.03	12.55
Hoogly	53.77	674.38	12.54
Burdawn	59.42	746.59	12.56

Birbhum	52.74	611.62	11.59
Bankura	52.19	857.58	16.43
Purulia	35.35	538.55	15.23
Midnapur (West)	58.22	870.82	14.95
Midnapur (East)	42.52	509.88	11.98
Total West Bengal	**954.18**	**13722.35**	**14.38**

Source : F.P.I. and H., Annual report, Government of West Bengal, 2012-2013

Regional imbalance in productivity

It is quite convincing from the above information that the productivity is not at all encouraging. The state of West Bengal is characterized by varied agro-climatic situations, which has resulted in the possibility of growing wide range of vegetable crops round the year. Huge intra-state difference in productivity from 10.95 t/ha in Darjeeling district to 17.58 t/ha in Coochbehar district is quite apparent from the production scenario of vegetable crops in West Bengal. It also indicates the inability in proper harnessing the production potentiality of different vegetables grown at different agro-ecological conditions of the state. Until recent years limited endeavour has so far been taken towards micro level planning in mitigating the imbalances in productivity. The reason behind this inability is the lack of analytical approach for identifying region specific micro level problem. Resource specific planning needs to be taken up in order to harness the full potentiality at micro level. Research and extension may be motivated in a meaningful direction so as to generate more employment utilizing the available resources at their level best. At the same time, though difficult, techno-economic feasibility must be studied for area expansion and or crop replacement in terms of number of crops, number of situations (both agro-economic and socio-economic) and obviously in methodology.

Basic features of vegetable farming in West Bengal

Cultivation of tomato and cabbage is overwhelmingly dependent (about 80%) on the hybrids different private seed companies. In other vegetable crops utilization of hybrids is very much limited viz., okra (15%), watermelon (15%), chilli (10%) and cauliflower (10%). Most of the tropical and tropicalized vegetable crops are cultivated in India utilizing wide array of indigenous "Farmer varieties". About 80% seeds of the open pollinated "Farmer varieties". of these vegetable crops viz. eggplant, chilli, pumpkin, bottle gourd, bitter gourd, wax gourd, snake gourd, ridge gourd, cucumber, okra, leaf amaranth, Indian spinach, hyacinth bean, cowpea, etc. are farmers' own saved seed. Farmers' saved seeds are not essentially the quality seeds which show genetic variation, poor field stand, and ultimately yield. However, the big private and corporate seed companies are not all willing to produce the seeds of the open pollinated varieties because of the risk on their profit making venture. In this situation, farmers' cooperative-led seed village for vegetable crops holds the key for strengthening local seed development systems and conserving the valuable genetic resources.

Strategy for increasing vegetable productivity

In the situation of marginal increase in cropping intensity during the last 15 years from 159 % in 1990-91 to 187 % in 2005-06 coupled with rapid industrialization and sprawling urbanization in the state, it will be rather impossible to increase the area under vegetable crops. In the present situation, instead of targeting the expansion of area, the main strategy should to enhance the productivity of vegetable crops excluding potato from the present low of 14.38 tonnes per hectare to at least 16.00 tonnes per hectare by 12th plan period.

Action plan

Stress on coverage of larger areas with the hybrids :

Concerted efforts need to be made to cover about 35-40% area under hybrids of different important vegetable crops viz, tomato, cabbage, okra, chilli, sweet pepper, cauliflower, bottle gourd, bitter gourd, cucumber, ridge gourd, pumpkin, watermelon, muskmelon, summer squash, etc.

Stress on seed production of vegetable crops :

Promotion of seed production of improved varieties/ F1 hybrids of vegetable crops capitalizing huge and low cost human resource should be the basic strategy for increasing productivity by ensuring quality seeds to the farmers and increasing profitability through export of vegetable seeds. Cluster of seed villages for the production of open pollinated and hybrid seeds may be organized in the western districts through cooperatives, public and private sector agencies with adequate training facilities.

Expansion of irrigation coverage :

Irrigation coverage need to be expanded through water shed development, renovation of different water bodies in the rural areas and judicious use of water by encouraging the use of drips and sprinkler system of irrigation.

Increase in capital inflow in vegetable production system :

Keeping in view that percentage of advances to deposits of scheduled commercial banks in West Bengal in rural areas (32.78%) being much below the National average (52.72%) as well as leading all the leading states, immediate steps need to be taken so that at least specific market driven and export oriented quality vegetable production can be tagged with short or medium term bank loans for ensuring capital in flow in total agriculture in the state.

Encouraging hi-tech vegetable production :

To bridge the vast gap between actual and potential productivity, there is urgent need to adopt efficient and mechanized vegetable production technologies which will not only increase productivity but also enhance the product quality, thereby, ensuring better returns to the farmers through i) development of Hi-tech nursery for production of healthy seedling, ii) protected vegetable cultivation around peri-urban areas, iii) efficient use of water and nutrient through drip/sprinkler irrigation and fertigation, iv) raised bed cultivation and use of organic/degradable biomass for mulching, v) promotion of precision farming for maximizing input use efficiency to get higher and quality return and vi) promotion of off-season production of vegetables.

Encouraging vegetable cultivation in poly house :

Precision farming of high value vegetable crops viz. coloured capsicum, celery, lettuce, etc. in poly house under controlled weather conditions need to be encouraged through subsidy and bank credit oriented facilities.

Declaration of special vegetable production zone :

Development of logistic support and infrastructure viz., roads, packaging station, multipurpose cold storage, truck terminal, transportation facility, processing set up and market intelligence in the special vegetable production zones viz., Kalimpong zone, Haldibari zone, Dhupguri-Falakata zone, Tufanganj zone, Islampur zone, Baharampur zone, Krishnanagar zone, Madanpur zone, Bangaon zone, Barasat zone, Bhangar zone, Jaynagar zone, Jhargram zone, Garbeta zone and Ajoyadha zone. Adequate provision for different inputs viz., seeds, fertilizers, micro-nutrient chemicals, bio-control agents, botanicals, bio-fertilizers, pheromone trap and recommended insecticides, antibiotics and fungicides for different vegetables. Structuring of Agri-business consortium in the special vegetable production zone and tying up of the exporters, intra-state traders and processing industries with the vegetable growers.

Increase availability of pack house facility :

Pack house facilities must be available near the cities and towns. At least one pack house facility equipped with washing, grading, pre-cooling and sorting facilities should be there in the 15 production zones. With some additional facilities, these pack house may serve as training centres and input distribution points.

Promotion of integrated plant nutrient management system (IPNS) :

The integrated plant nutrient system (IPNS) includes the balanced use of chemical fertilizers; organic manures and biofertilizers which not only increase the productivity in sustainable manner but also take care the soil health and productivity. The IPNS system is more result oriented in protected vegetable cultivation where crop rotation and soil replacement is a highly difficult task. It will be more effective and sustainable if both IPNS and IPM systems are adopted together.

Promotion of integrated pest management (IPM) :

It is the eco-friendly system approach in both strategies and technologies to reduce the dependence of chemicals for controlling the pest and diseases. Nevertheless, multiple support and co-operation from public and private organizations is needed to harness full potential of available technologies and strategies. Use of resistant/ tolerant varieties

Post harvest management :

Governmental policy interventions are needed for adequate post harvest management of the produce through the development of production centres based on cluster village concept and establishment of processing units which may include input subsidies for establishment of cool chain, processing into value-added products, pricing policies, import/export tariffs and facilities for marketing.

Development of quality control laboratory :

Development of quality control laboratory for testing the pesticide residue and other nutritional qualities under the supervision of Agricultural Universities is necessary in the interest of enhancing the export of vegetables and processed products in the state.

Improvement/Establishment of regular markets/strengthening fresh vegetable marketing :

More regular markets for vegetables need to be established at suburban areas, town, and metropolises and the existing markets need to be modernized to encourage not only efficient marketing but also assure good quality and hygienic produce to the consumer. The condition of the weekly or bi-weekly big markets in the rural areas, local markets in the suburban areas need to be improved through providing adequate space, cleanliness inside the market and efficient transport facilities.

Mechanisation of vegetable farming :

Precision farming and less labour intensive but efficient vegetable farming need mechanization in the different farming practices viz., direct seed sowing, transplanting, weeding, hoeing, spraying, harvesting etc. So, adequate and cost effective machinery and tools should be made available to the farmers with proper demonstration facilities.

Crop diversification :

Most of the vegetables are short duration and are suitable for growing in mixed, relay and companion cropping systems. Taking this advantage, crop diversification among the vegetables, the underutilized and exotic vegetables rich in nutrient for both domestic as well as export markets should be promoted through adoption of different developmental schemes. Some of these vegetables which need to be promoted are sweet corn, baby corn, moringa, leek, bunching onion, welsh onion, broccoli, brussels sprouts, Chinese cabbage, pointed gourd, kakrol, kartoli, ivy gourd, sweet gourd, faba bean, summer bean, lima bean, winged bean, sword bean, velvet bean, etc.

Emphasis on organic farming of vegetables :

In the export of total food sector, organic sector is considered a suitable niche. Market shares of organic foods in most developed countries are around two percent of total food sales. Somewhat higher figures are found in some West European countries (eg., Australia, Denmark, Switzerland) with estimated organic shares close to 3 per cent. Further, the share of organic sales in vegetable sector is somewhat higher than the share of organic sales in total food sales. In most developed countries, organic shares in vegetables are estimated upto 10 percent in the Switzerland and in the United Kingdom. Export preference of organic vegetables offer great scope to country like India, which has inculcated the skill of growing organically since long time. Emphasis should be given to encourage organic production of vegetables in the forest fringe areas which are organic by default due to almost no use of inorganic inputs in cultivation.

Development of Bio resource centre for conservation of genetic resources :

Setting up of at least one bio resource centre for conservation of available diversity in vegetable crops under the supervision of State Agricultural University.

Developemnt of Plant health clinic :

With the shrinking land resources, more intensive crop husbandry and even more complex agri-horticultural production and marketing systems, the agro-biologists do face newer and intricate problems in combating different biotic stresses caused by fungi, bacteria, virus, insect pests, nematodes, rodents, weeds and abiotic stresses caused by nutrient deficiency, soil reaction, high temperature and high moisture condition. It is must now to understand these stress factors, their mode of action and preventive measures with greater precision and vigour with strong laboratory support. Plant health clinic is district or specific production zone level laboratory based and service oriented project for the growers and other stake holders to elevate their skill and operative standards to produce high quality and safe product through Good Agricultural Practice.

Vocational courses for entrepreneurs/Master farmers :

Development of knowledge base to the progressive vegetable growers through vocational courses particularly on "Good Agricultural Practices" for the production of the safe produce, appropriate pre and post harvest technologies to extend the availability of the produce, codexes for pesticide residue level, integrated plant nutrient management system and integrated pest management system.

Awareness on the benefits of fruit and vegetables :

Educational activities for pre-school children including puzzles, posters and songs and framing of television and radio programmes on the benefits of fruit and vegetables, their proper washing, storage, healthy preparation, and cooking methods.

Establishment of Biotechnology Board :

At this juncture without the existence of State Biotechnology Board, it will not be wise to put even trials on GM vegetable crop. A clear-cut policy in the state need to be framed with the establishment of "State Biotechnology Board" keeping experts in the area of Biotechnology, Genetics and Plant breeding, Crop management specialists, representatives of Industry and also the stakeholders so that it is ensured through strict vigilance that the GM products will not destroy the environment, will not cause the development of resistance in the target insect pest to the transgenic product and moreover, be safe.

Sustained research and developmental activities :

At a very conservative estimate of Rs. 5000/- per tonne of vegetables the value of annual produce in West Bengal may come around 7000 crore. However, budgetary outlay of the Government for research and developmental activities is really negligible. Policy decision needs to be taken to bring fund in the Agricultural Universities and Research Institutes from the private sector for carrying out mission oriented research and developmental activities on priority aspects of vegetable crops.

Conclusion:

It is very difficult to cope up with the rising demand of food grains and at the same time, overwhelming dependency on food grains caused rampant malnutrition, the very feature of India. The value of vegetables goes beyond the provision of necessary vitamins, minerals, micronutrients and in a number of cases, protein. Vegetables are particularly important source of micro-nutrients viz. Calcium, phosphorus, iron and magnesium vitamins especially provitamin a, vitamin c, vitamin b2, thiamine and folic acid and dietary fibre. About 90% of human dietary vitamin c and 50%of vitamin a requirement is fulfilled from fruits and vegetables. Although, vegetables do not contain an active vitamin a, they are rich source of provitamin a (ß carotene), which are readily converted into active retinol (vitamin a) in the liver and intestine. Despite lycopene of tomato and tomato-based food products having no provitamine a activity, this specially unsaturated carotenoid presents very particular health benefits through its powerful antioxidant properties. In addition, vegetables also supply fair amount of carbohydrates, proteins (7%) and calories (10%). Dietary factors that enhance non-haem iron absorption include ascorbic acid, meat, poultry, fish and other seafood and low ph namely lactic acid and in south asia including india where meat intake is low , ascorbic acid (vitamin c) emerges as one of the most important enhancers of iron absorption. Diets rich in vegetables are associated with various positive outcomes such as reduced incidence of lung cancer, beneficial effects for kidney function reduce coronary artery disease, diabetes and several cancers, slow down age-related declines in brain function and in cognitive and motor performance.

References :

1. National Institute of Nutrition – Annual Report, Hyderabad (2013-2014)
2. http://dspace.hoasen.edu.vn/...(65)%20Dietary_Supplements_and_Functional%2.
3. Indian horticulture database 2013 (nhb.gov.in/area-pro Indian%20Horticulture%202013.pdf)

A HAND ON MANAGEMENT PRACTICES FOR VEGETABLE CULTIVATION AND THEIR ECONOMIC PROFITABILITY FOR BETTERMENT OF LIVELIHOOD FOR LOWER LEVEL BENEFICIARIES

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Rational :

Vegetables improve life expectance by providing essential vitamins and minerals to our body. In average daily 300 gm vegetable is required for a person. However now only 175 gm vegetable is available to a person in India. So there is urgent need to increase the yield in sustainable way. This can be achieved by increasing the land area under vegetable cultivation and/ or improving the productivity. Former is practically difficult to do because suitable land for vegetable grow is limited. In this case later is only option to increase the vegetable production. And for that INM & IPM along with maintaining good soil health, the ultimate goal of higher production may be achieved.

A guideline for sustainable production for selected vegetable crops which are commonly practice in West Bengal is presented here in a tabular form (Table-I) for ready reference. As a thumb rule for ensuring high productivity, selection of healthy seed and scientific seed bed preparation should be followed.

Basic Infrastructure needed :

Establishment of the following infrastructures are essential. for increasing the yield production and that is expected to be developed by Institution so that resource starved farmers can profitably engaged in Agriculture.

1. New pond/ tank construction and renovation of old pond/ tank for rain water harvesting and subsequent irrigation facilities.
2. Availability of sufficient good quality seed, vermicompost, fertilizer, micronutrients, pesticides, technology and marketing facilities.
3. Proper dosages of fertilizer and soil amendment are to be used on soil test basis.
4. Cold storage construction in vegetable belt.
5. Better communication (road) system for easy and fast transport of perishable vegetable.
6. Simplifying Banking loan to farmers.
7. Regular training and demonstration for vegetable cultivation.

Management Practices (Table-I)

Table I : Management Practices of some important vegetables and their economics for a one Bigha land.

Sl. No.	Vegetable (Variety)	Suitable Weather // Soil	Seedling (No.)/ Seed (gm)	PxR Distance (Time of Sowing/ Transplanting)	Land preparation	Fertiliser application (kg)		Maintenance	Irrigation	Yield (quintal)/ Cost (Rs.)/ Profit (Rs.)
						Basal	Top dressing			
1	Pointed gourd (Swarna rekha, Swarna aloukik)	Hot & humid // Sandy loam, loamy	1200 female & 135 male	1 m x 1 m (February/ Sept.)	45 cm deep ploughing, 3/4 times; Before last ploughing apply 2 ton FYM, 17 kg mustard cake, 17 kg neem cake	Urea- 14 SSP 25 MOP- 7	Urea – 5 (at the time of leaf emerging) Urea- 10 (after 2 months of above)	After transplanting the seedling place the straw at base of plant. Construct Mancha	Land should be moist during the growing period; normally 3 times in week at summer	40-50/ 12000/ 30000
2	Ridge gourd (NS441, NS-3, Rekha, Rohini, Sarpara, Surekha)	High rainfall & humidity (70-90%), temp 25-35^{0}C // Sandy loam (rainy season), clayey & clayey loam (summer season)	660- 830 gm (12 hrs socking in water & if possible germinate the seed)	3 ft x 4 ft for mancha	2-3 times ploughing; Apply ¼ busket FYM + 20 gm neem khol + 10 gm urea + 30 gm SSP + 10 gm MOP in each pit		Urea- 6 (22 DAS) Urea- 6 (at the time of flower emerging)	15 DAS arrange suitable climbing condition; plugging of vegetable is best at 2 -3 days interval	Irrigate the land such a fashion so that soil should be moist throughout growing season	20 (Deshi)-50 (Hybrid)/ 15000/ 15000
3	Bitter gourd (Short variety (Local), Long variety (Pusa-Mousumi, Megha, Arka Kundan etc)	Hot & humid, 120- 140 cm rainfall & temp 20-25^{0}C // Sandy to clayey loam (summer), as above including red /.(rainy), .Clyey to Clayey loam	590- 830 gm (Summer & Rainy), 830 1000 gm (Winter) (12 hrs socking in water & if possible germinate the seed)	6 ft x 6 ft (Summer & Rainy) 4 ftx 4 ft (Winter) Note: Seed sow 3-4 days after basal dose of fertilizer	2-3 times ploughing; apply 1.5 ton FYM & 17 kg Neem cake in pits	U- 10 10:26:26- 33	U- 10 (25 DAS); U- 10 (50 DAS); Spray urea @ 4 gm per liter in each week;	Plant is sensitive to water logged situation but soil is to be moist continuously; Spray Miraculan @ ½ ml per liter of water at 15 days interval; Hormone such as GA-3 @ 10 mg per liter spray in each month to improve the	Soil must be continuous moist. Rainy irrigate as required. Winter- once in a week. Summer-	17-20 (rainy), 10-13 (winter), 7-8 (summer)/ 12000/ 15000

		(winter)		application				productivity; Construct Mancha for Rainy and Summer season.	twice in a week	
4	Cucumber (Summer- Bardan, Japanise, Long green, Swarna-sital; Swarna-kopot Rainy- Japanise, Long green, Swarna-sital Winter- Bardan, Swarna-sital)	18-35^{0}C, dry & wet both weather, bright light // Rainy - course texture soil, Summer- fine texture, Winter- any type of soil	330 gm (Summer), 330 gm (Winter), 250 gm (Rainy) (12 hrs socking in water)	2 ft x 3 ft (Winter & Summer- sowing on Jan.- Feb.), 4 ft x 5 ft (Rainy- sowing on April- May)	2-3 times ploughing; apply 1.5 ton FYM, 8 kg Neem cake & 8 kg Bone dust in pits	U- 12 10:26:26- 33	U- 10 (20 DAS); U- 10 (35 DAS)	Spray Miraculan @ ½ ml per liter of water at 15 days interval; Hormone such as GA-3 @ 10 mg per liter spray in two times (when 2-4 leaves stage & then exactly one month later); Construct Mancha for Rainy and Summer season.		20-25 (rainy & summer), 15-20 (winter)/ 12000/ 15000- 20000
5	Cabbage (Early-Green express, Golden acre, Pride of India; Mid duration - Rare ball, Sonia, Pusa-mukta, Mitra; Late- Pusa drum head, Pusa late drum)	Best for winter however in rainy season it can be grown, bright light prefer // Rainy - course texture soil, Winter- loam to fine texture	65-70 gm (Early); 45-50 gm (Mid duration & Late) For seedling- 5000 nos.	1 ft x 1.5 ft (Early- Aug.) 1.5 ft x 2 ft (Mid duration- Sept. & Late- Oct.)	2-3 times ploughing; Before last ploughing apply FYM 2 ton; Neem or Mustard cake - 80-100 kg; Lime- 50 kg (in general, however it is recommend as based on soil test)	Early & Local variety- U- 10 10:26:26- 50 Mid duration & Late, Hybrid U- 10 10:26:-26- 56 Micronutrients (based on soil test) Zinc sulphate - 8 kg, Borax- 1 kg, Sodium molybdate - 200 gm	Early & Local variety- U- 15 (20 DAT); U- 15 (35 DAT). Mid duration & Late, Hybrid- U- 15 (20 DAT); U- 15 (35 DAT)	Weeding at 28-30 days and then earthen up.	Rainy- well drain system & irrigate only when required. Winter- once in a week.	30 (Early), 50 (Mid duration)/ 10000/ 10000
6	Cauliflower (Early- Contasa, Early market, Pusa kotki; Mid duration - Early snowball, Patnai mail group, Contasa; Late- Late snow ball, Dania,	Best for winter however in rainy season it can be grown, bright light prefer // Rainy - course texture soil, Winter- loam to fine	Rainy- 50-55 gm (Early); Winter- 70-75 gm (Mid duration & Late) For seedling- Rainy- 10000 nos., Winter- 4000 nos	1 ft x 1.5 ft (Rainy- June/ July) 1.5 ft x 1.5 ft (Winter -Mid duration: Aug./ Sept. & Late: Nov.)	2-3 times ploughing; Before last ploughing apply FYM 2 ton; Neem or Mustard cake - 80-100 kg; Lime- 50 kg (in general,	Early & Local variety- U- 11 10:26:26- 50 Mid duration & Late, Hybrid U- 12 10:26:26- 56 Micronutrients (based on soil	Early & Local variety- U- 11 (20 DAT); U- 11 (35 DAT). Mid duration & Late, Hybrid- U- 12 (20 DAT); U- 12 (35 DAT)	Weeding at 28-30 days and then earthen up.	Rainy- well drain system & irrigate only when required. Winter- once in a week.	5-7 (Rainy), 12-15 (Winter)/ 13000/ 30000

	Pusa kashmiri)	texture			however it is recommend as based on soil test)	test) Zinc sulphate - 8 kg, Borax- 1 kg, Sodium molybdate - 200 gm				
7	Tomato (Early- S-22, Swarna lalima, Swarna navin; Mid duration - Ankur-300, Avinash-2, NP-5005; Late- Rupali, NP-5005, BSS 3000)	Temp 9-27⁰C, slight tolerant to cold & hot climate // Rainy- Laterite, Winter- clay & loam, Summer- Clay loam & clay	40-50 gm (Rainy), 25 35 gm (Summer & Winter) Seedling- 2000-2250.	2 ft x 2.5 ft (Winter- sowing on Oct., transplanting on Oct./ Nov. & Summer- sowing on Jan.- Feb.), 4 ft x 5 ft (Rainy- sowing on April- May)	2-3 times ploughing; Before last ploughing apply FYM 2 ton; Lime- 50 kg (in general, however it is recommend as based on soil test	Early & Local variety- U- 11 10:26:26- 50 Mid duration & Late, Hybrid U- 12 10:26:26- 56 Micronutrients (based on soil test) Zinc sulphate - 8 kg, Borax- 1 kg, Sodium molybdate - 200 gm	Early & Local variety- U- 11 (20 DAT); U- 11 (35 DAT). Mid duration & Late, Hybrid U- 12 (20 DAT); U- 12 (35 DAT)	Weeding & earthing at 21 & 42 DAT, Construct Mancha	Irrigate cautiously, should not be too moist. Irrigate frequentl y.	40-50 (Rainy), 60-70 (Winter, Deshi, Summer), 100-110 (Winter- Hybrid)/ 15000-17000/ 20000-30000
8	Capsicum (Heera, Indra etc)	Cold temp. (18-30⁰ C& low humidity // Well drain loamy soil rich in organic matter	3500/ 200	1.5 ft x 2 ft (Sowing- Aug.- Sept., Transplanting- Sept.- Oct.)	2-3 times ploughing; Before last ploughing apply FYM 2 ton, basal dose of fertilizer, micronutrint, Furadon 3G (4 kg), Bentonite sulphur 3 kg.	U- 19 10:26:26- 40	U- 9.5 (22 DAT); U- 9.5 (42 DAT)	Weeding should be done at 22 & 42 DAT and earthing up should be done. First flower should be pinched off. Apply liquid sulphur before flowering.	Regular light irrigation should be given.	15-20/ 15000/ 25000-30000
9	Chilli (Suryamukhi, Pusa jwala, Bullet, X-235, ARCH-226)	Temp.- 18-30⁰C // Rainy- Sandy loam & Lateritic Soil, Winter- all type of soil.	5000/ 70 (Rainy & Summer) & 90-100 (Winter)	1 ft x 1.5 ft (Summer- Sowing on Feb.- March, Transplanting on March-	2-3 times ploughing; Before last ploughing apply FYM 2 ton, basal	U- 8 10:26:26- 40	U- 8 (22 DAT); U- 8 (42 DAT)	Weeding should be done at 22 & 42 DAT and earthing up should be done. Apply planofix at the time of flowering.	Regular light irrigation should be given.	20-27 (Summer & Rainy), 30- 35 (winter)/ 6000/

				April) (Rainy- Sowing on May- june, Transplanting on June- July) (Winter- Sowing on Sept.- Oct., Transplanting on Oct- Nov.)	dose of fertilizer, micronutrint, Furadon 3G (4 kg).					15000
10	Brinjal (Summer- Nischintapur; Pusa purple cluster, Swarna prativa; Rainy- Pusa purple round, Pusa long green, Swarna sobha; Winter- Blue star, PK- 123,Srarna pratibha)	Tropical to sub tropical, temp. - 15-25^{0}C // - -	2400/ 60-70 (Rainy & Summer) & 80-90 (Winter)	2 ft x 3 ft (Rainy) 1.5 ft x 2.5 ft (Winter & Summer)	2-3 times ploughing; Before last ploughing apply FYM 3 ton, basal dose of fertilizer, Neem cake- 20 kg, Mustard cake- 20 kg, Furadon 3G- 4 kg.	U- 12 10:26:26- 55	U- 12 +Mustard cake- 20 kg (21 DAT); U- 12 +Mustard cake- 20 kg (42 DAT)	Weeding should be done at 21 & 42 DAT and earthing up should be done. Older leaves should be removed.	Summer- 2 times in a week, Rainy- according to requirement. Winter- 1 time in a week.	Summer & Rainy- 16-20 (Deshi), 26-30 (Hybrid); Winter- 26-30 (Deshi), 35-40 (Hybrid)/ 17000/ 20000
11	Ladies finger (AROHI0, Pusa makhmali, Pusa kranti)	Hot & humid, Rainfall- 100-150 cm, Temp.- 20-35^{0}C // Soil pH- 6.0-6.8, Rainy & Winter- Sandy, loam, Lateritic; Summer- Clay	1300- 1500 gm (12 hrs socking in water & sowing should be done at afternoon)	2 ft x 3 ft (Rainy) 1 ft x 1 ft (Winter)	2-3 times ploughing; Before last ploughing apply FYM 2.5 ton, basal dose of fertilizer, Bone dust- 30-35 kg, Mustard cake- 15-17 kg, Furadon 3G- 4 kg.	U- 10 10:26:26- 27	U- 8 +Mustard cake- 7 kg (20 DAS); U- 8 +Mustard cake- 7 kg (40 DAS)	Weeding should be done at 20 & 40 DAS (Summer); Weeding should be done at 20, 40 & 60 DAS (Rainy).	Summer- 1 time in a week, Winter- 2 times in a week.	6-7 (Deshi), 10 (Hybrid)/ 8000/ 10000
12	Radish (Winter- Pusa	Temp.- 15-25^{0}C // Loamy soil	660- 800 (Broadcasting),	8 inch x 8 inch Winter- Dec.-	2-3 times ploughing	Urea- 13 SSP 30	U- 16 (15 DAS)	Remove the excess seedling after	Summer- at every day	33-40 (Winter),

	himani. Autumn- Japanese whit, Contai long, Rainy- Pusa deshi, Chinese rose, Summer- Pusa chetaki)		500- 660 (Sown in line)	Feb. Autum- Sept.- Nov. Rainy- Aug.- Sept. Summer- April- July	upto 6-8 inches depth; Before last ploughing apply FYM 2 ton, basal dose of fertilizer, Neem cake- 40 kg, Mustard cake- 7 kg.	MOP- 10		emergence	interval, , Winter- 2 times in a week.	20 (Summer/ 4500/ 8000- 10000
13	Spinach (Verginia, Savoy, Algreen, Jobner green, Pusa jyoti)	Cold climate // Acidic, Loamy, Rich in organic matter.	Broadcast (Small leaf variety) 4-5 Kg. Sown in line (Large leaf variety) 2.6-3.3 Kg.	(Large leaf variety) 15 cm. x 30 cm. September - December	2-3 times ploughing. Before last ploughing apply 2-3 ton FYM, Basal dose of fertilizer.	For small leaf variety U-3 SSP- 50 MOP- 17 Neem cake – 17. For large leaf variety U- 7 SSP- 70 MOP-20 Neem cake- 20	For small leaf variety Urea- 3. after every cutting. For Large leaf variety Urea- 7. after every cutting.	Weeding should be done after 2 weeks from the seed sowing.	2 times in a week.	Small leaf variety 10- 12 Large leaf variety 20- 27/ 4,500/ 10,000
14	Vegetable Pea. (Early var- Arkel Meteor, Early bazaar) (Late var- Krishnanagar dwarf, Pant uphar, Boneville, Azad, New line)	Cold and dry, Tempereture - 12 C – 20 C. // Sandy loam for Early variety and Loam for late variety.	Early var. 10– 12 Kg. Late var. – 7 – 8 Kg.	10 cm. x 15 cm. Early – Sept – Oct. Late – Oct – Nov. Seed should be treated with Rhizobium.	2-3 times ploughing. Before last ploughing apply 1.5 Ton FYM, Neem cake- 16 Kg, Basal dose of fertilizer.	SSP– 32 MOP-10	1st, Urea – 2.6. (22 DAS) 2nd, Urea – 3.3. (At the time of flowering)	Weeding should be done 15 days after sowing. Spray Miraculan @ 1 ml./ 7 liter water.	2 times in a week.	Early– 3 - 4 Late – 5 – 6/ 5,000/ 15,000

				before sowing.						
15	Onion. (Small Tuber var.- Muri, etc.) (Large Tuber var. – Pusa red, Nasik red, Pusa white, Sukhsagar)	Cold & dry, temp. at first phase of growing 15-25OC, last two months 20-30OC // -	For small tuber var.- Tuber – 135 Kg. For large tuber variety- Seed- 2 kg	For small tuber var.- tuber to tube r- 15 cm, Row to Row- 30 cm. For large tuber var.- seedling to seedling- 10 cm, Row to Row- 15 cm. Time- Oct. to Nov.	FYM2 ton, basal fertilizer at the time of last ploughing For small tuber var.- tuber is planted then slight irrigation is done For large tuber var.- puddling is done after that seedling is transplanted.	U- 10 MOP- 13 10:26:26- 30	U- 20 (30 DAT) Bone dust- 15	Apply Basalin (7 DAT), weeding & loosening of soil (30 DAT) then apply wood ash	Keep the field moisten continuously.	Small tuber - 25-30, large tuber - 40-50/ 9000/ 15000

DAP= Days after plantation; DAS= Days after sowing, DAT-Days after transplanting , U - Urea, SSP- Single Super Phosphate, MOP- Muiate of potash

Table: Insects, affected vegetables and control measures

Sl. No.	Insect	Affected Vegetables	Symptoms	Control Measures
1	Brinjal shoot and Fruit borer	Brinjal, Tomato, Lady's finger	Peak during rainy season, Caterpillars bore into tender branch apex and petiole, and enters into mid ribs and feeds the inner soft tissues resulting bended shoots. Affected leaves and shoot wither and dry. At latter stage of growth, caterpillars bore into flower buds and fruit. Damaged flower buds shed and fruits show circular holes.	1. Apply 20gm Neem cake for each plant at the time of land preparation. 2. Apply 1 gm Cartap hydrochloride for each plant at the base of plant, 7 DAP. 3. Spraying of liquid formulation of Cartap hydrochloride @ 1 gm / liter of water at every 7 days interval starting from 21 DAP. 4. Installation of pheromone trap for Leucinodes orbonalis @ 50/ ha. starting from 20 DAP. 5. Alternatively spraying of Spinosad, Cypermethrin+quinalphos, deltametrin, flubendiamide, thiacloprid etc.
2	Ants	Cauliflower, Cabbage, Knol-khol, Brinjal, Chilli, Cucumber	Ants gather at the growing tender shoots and destroy it, sometimes they cut down the young seedlings of vegetables.	1. Ploughing should be done properly. 2. Sparying of Sevin dust. 3. Spraying of chlorpyriphos @ 2 ml/ liter of water.

3	Termite	Caulliflower, Cabbage, Knol-khol, Brinjal, Tomato, Bottle gourd, Pumpkin	It appears in dry condition of soil. If the water scarcity is happened after plantation, termite infestation is increased. They cut the base of the seedlings. Seedlings become died very soon.	1. Ploughing should be done properly. 2. Spraying of Dursban @ 1.5ml/ liter of water at the base of the seedling.
4	Mealy bug	Pumpkin, cucumber, Ridge gourd, Lady's finger, Dolichos bean(sim)	Their body is very soft and reddish white in colour, bodies are covered with an white cottony waxy scales. They forms a colony at a place and stays together. They suck the plant sap from the inflorescence and young fruits.	1. Spraying of systemic insecticides as, Metasystox @ 1 ml / liter or, Parasystox @ 1 ml / liter, Imidachlorprid @ 3 ml / liter of water.
5	Epilechna bettle	Bitter gourd, Ridge gourd, Snake gourd, Tomato, Brinjal	Peak period July to October. Grubs and adults feeding on the green portion leaving behind only a network of veins.	1. Collect and destroy egg masses a nd skeletonized leaves with adults and grubs. 2. Spray Dipterex @ 2 gm / liter of water at 15 days interval two times. 3. Spray Endosulfan, Carbaryl, Neem based pesticides.
6	Aphids	Bean, Dollchos bean (sim), Ridge gourd, Bottle gourd, Radish, Cowpea	Incidence period November to March, nymphs and adults (blackish green) appears – annumerously on tender shoots and inflorescence and suck the plants sap. As a result lowering of vitality, downward curling of leaves, flowers become small and do not open.	Spraying of dimethoate @ 1 ml/ liter water or thiomethoxam @ 1 ml/ liter water or Imidachloprid @ 3 ml/ 10 liter water or acetamiprid @ 2 gm/ 10 liter water.
7	Red spider mite	Ridge gourd, Bottle gourd, pumkin, snake gourd, Cucumber, pointed gourd, Tomato, Brinjal, Lady's finger, Cowpea	Red coloured spider mites infests the crop very extensively during pre monsoon and post monsoon periods. Infested leaves show needle head like white spots. Turning yellow then brown. Premature defoliation, withering sympt oms and stunted growth of leaves affecting severe yield loss.	Spraying of dicofol 18.5 or spiromecifen 240 SC or Fenzaquin 10 EC or Propergite 57 EC or Abamectin 1.9 EC.
8	Yellow mite	Chilli	The mite causes serious damage in chilli, shows curling, inverted boat shape appearing and elongation of petiol. Leaf size becomes very small, stunted growth of apical shoot as a result no bud and fruit formation takes place. Peak infestation period - March to September.	Spraying of dicofol 18.5 or spiromecifen 240 SC or Fenzaquin 10 EC or Propergite 57 EC or Abamectin 1.9 EC.

9	Jassid	Tomato, Brinjal, Lady's finger	Period of incidence March- July, sucking sap from the plant causing leaf shriveling and downward bending of leaf edge. They transmit little leaf mycoplasma disease and virus disease also.	Spraying of Dimethoate @ 1 ml/ liter water or Deltamethrin + triazophos @ 1 ml / liter water or Imidachloprid @ 3 ml /10 litre water
10	White fly	Cucumber, pointed gourd, Tomato, Brinjal, Lady's finger, cucurbits	Both the nymphs and adults suck the plant sap as a result affected parts become yellowish, leaves wrinkle, curl downwards and are ultimately shed. They transmit yellow vein mosaic virus.	Place yellow adhesive trap so that the attracted flies get stuck with the sticky surface of the trap. Spray Pyriproxyfen + fenpropathrin, or fenpropathrin, or Profenophos, or Thiomethoxam. Avoid use of synthetic pyrethroids, like deltamethrin, cypermethrin etc.
11	Diamond back moth (DBM)	Cauliflower, Cabbage, Knol-khol	Peak period February to April. Leaves are skeletonized by larvae, causes severe damage.	1. Installation of pheromone trap for DBM. 2. Transplant 2 rows mustard as a trap crop for every 25 rows of cabbage. 3. Spray Spinosad, or indoxacarb, or flubendiamid, or Difenthiouron. 4. Apply Neem based formulation or Btk or Beauveria bassiana at recommended dose mixing with sticker.
12	Red pumpkin beetle	Cucurbits	Peak period March to October. Red coloured beetles sometimes black spots are found on red coloured wings. Adults feed on foliage, bud and flowers. Grubs feed on roots, leaves and fruits lying in contact with the soil.	1. Soil drenching with Chloropyriphos, Endosulfan, Metarrhizium anisoplidae. 2. Spray Monocrotophos, Carbaryl. DDVP, Endosulfan, Neem based formulation.
13	Leaf miner	Cucurbits, Tomato	Pale yellow maggots mine into the leaf and feed on the mesophyll of the leaf making serpentine mines.	1. Soil drenching with Thiomethoxam @ 100gm a.i in 1000 litre of water per hectare. 2. Spray Triazophos, or Acetamiprid, or DDVP at recommended dose.
14	Leaf eating caterpillar	Cucurbits, Cowpea, Spinach, Amaranthus spp.	They eat the whole leaf or skeletonize the leaf. Specially they attack, the young tender leaf.	Spray Carbaryl, or Quinalphos, or Chlorpyriphos, or Cypermethrin.
15	Spodoptera litura	Cabbage, Cauliflower	Early instar larvae skeletonize the leaves from underside, grownup larvae damage the foliage at night, bore into the head of cabbage. Peak period of activity September to November and February to April.	1. Grow castor around the field. 2. Spray Spinosad, or Indoxacarb, or Fenvalerate, or Difenthiouron etc.
16	Aphids	Chilli, Tomato, Brinjal, Lady's finger	They suck the plant sap from the leaves. Leaves become curly and bend upwardly. Flower and fruit drop occurs. Growth of plants becomes checked.	Spray Imilachloprid @ 3 ml/ 10 liter water, or Thiomethoxam @ 1 ml/ 1 litre water, or Dimethoate @ 1 ml/ liter water.

Table: Disease of vegetables caused by fungus, bacteria, virus and other factors, and their control measures

Sl. No.	Disease	Affected vegetables	Symptoms	Control measures
1	Damping off	Brinjal, Tomato, Chilli, Cabbage, Cauliflower etc.	(Fungal disease) The disease is more prevalent in nursery beds, both in pre and post emergence stages. Sudden collapse of healthy seedlings is a common symptom. The infected tissues at the ground level appear soft and water soaked with the progress of the disease, the stem becomes constricted at the base and the plants topple down.	1. Sterilization of nursery bed by (solerization,or bleaching powder, or formaline) 2. Seed treatment with Captan 50 WP, Or Thiram 80 WP, or Pseudomonas fluroscence @ 5 gm/ kg seed, Trichoderma spp. @ 4 gm/ kg seed. 3. Drenching the crop with Captan 50 WP at the recommended doses.
2	Blight	Brinjal, Tomato, Chilli, .	(Fungal disease) Brown, blackish water soaked patches appear on leaves and stem, pale water soaked sunken spots develop on fruit. In case early blight, small irregular dark brown to black in colour with concentric rings appear on leaves. Dyeing of leaves, rotting of stem and premature fruit drop are found.	1. Seed treatment with systemic fungicides like Carbendazim 50 WP, or Carbendazim 12% +Mancozeb 63% at the recommended doses. 2. Spray Propineb 70 WP, Mancozeb 75 WP, Mancozeb 75 WP+ Copper oxychloride50 WP, Metalaxyl 8% + Mancozeb 64 %, Fenamidone 10 +Mancozeb 50-60 WG, Propineb 61% + Improvalicarb 5.75% - 66.75%WP.
3	Downy mildew	Pea, cucurbits, Tomato	(Fungal disease) Yellow, brown angular patches found on leaves which turn brown. White cottony (Downy) growth are found undersurface of leaf latter the cottony growth turn purplish. Few misshaped fruits developed.	Spray Metalaxyl 8% + Mancozeb 64 %.
4	Powdery mildew	Pea, Cucurbits	(Fungal disease) Tiny white superficial spots appear on the leaf surface and stems, which become powdery as they enlarge. The powdery mass covers the entire surface of leaves and premature defoliation occurs, fruits are undersized.	Spray Sulphur 80 WDG or 80WP, or Carbendazim 50 WP, Triadimefon, Flusilazole25 WP at recommended dosages.
5	Rust	Dolichos bean, French bean, Cow pea	(Fungal disease) Small brown coloured swollen spots are found on leaves and fruits. Sometimes these are found on both the surface of the leaves latter on it turns to black. Severe loss in yield is found.	Spray Carbendazim 50 WP, or Benomyl 50 WP.
6	Stem rot	Bottle gourd,	(Fungal disease) Water soaked lesions on the stem which coalesces and the entire region rots. The tip of the vine withers leading to a poor popula tion of	Spray Metalaxyl 8% + Mancozeb 64% 72 WP, or Azoxystrobin 25 SC, or Fenamidine 10 + Mancozeb 5060 WG, or Fosetile Al 80

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		Pointed gourd	vines. In case of bottle gourd stem at the base region near the soil surface ruptures , some liquid oozing is found. In case of severe infection the fruit develops water soaked lesions which become sunken and rots.	WP.
7	Fungal wilt	Brinjal	(Fungal disease) The leaves of affected plants become flaccid and turn yellow. There is often premature drooping of flowers as also the leaves. As the disease progresses the plants wilts and die prematurely.	1. Seed treatment with Captan 50 WP, or Thiram 75 WP, or Pseudomonas fluroscens, or Trichoderma spp. 2. Incubate Trichoderma in compost @ 1 gm Trichoderma per 20 gm of compost should be applied in the soil @ 25 gm per sq. meter area. 3. spray Mancozeb 75 WP , Carbendazim 50 WP. at the recommended dosages
8	Die back or Twig blight or Fruit rot or Anthracnose of chilli	Chilli	(Fungal disease) Braches of infected plants are blighted and die at the time of flowering and fruit setting. Disease starts from blossom end. Black depressed spots are noted on the fruits. Small black, circular spots appear on the skin of the fruit. Fungal growth with spores can be seen on these sunken areas of infected fruit.	1. Seed treatment with Thiram 75 WP, or Carbendazim 50 WP. 2. Spray Carbendazim 12% + Mancozeb 63% 75 WP, or Hexaconazole 5 SC, or Tebuconazole 25 EC, or TRicyclazole 75 WP.
9	Black rot	Cole crops	(Bacterial disease) Chlorosis of leaf margin which progresses towards the centre of the leaf. Veins and veinlets turn brown and finally black leading to whitening of leaves. Bacterial ooze may also be seen from affected plants.	1. Crop rotation with non cruciferous crop. 2. Application of Streptocycline at the recommended dosages.
10	Bacterial wilt	Brinjal, Tomato	(Bacterial disease) This disease occur at flowering and fruiting stage of crop. Older leaves turn yellow, new tender leaves scatter horizontally, sudden wilting of plants having flowers fruits occurs. Xylem tissues of stems turn as brown colored.	1. Apply Plantomycin @ 0.25 mg per litre of water at the base of plant. 2. Streptomycin 50 mg + tetracycline 50 mg per liter of water at the base of plant.
11	Yellow vein mosaic	Lady's finge	(Viral disease) Most severe disease of lady's finger (Okra) all over India, limiting cultivation of the crop. Yellowing of the entire network of veins in the leaf blade is the characteristic symptom. In severe infection, the younger leaves turn yellow, become reduced in size and the plant is highly stunted. In a field most of plants may be diseased and the infection may start at any stage of the plant growth. Infection restricts flowering and fruiting, if formed, may be smaller and harder. The virus is transmitted by the white fly (Bemisia tabaci)	1. Use resistant varieties like Arka Anamika, Arka Abhay. 2. Apply Carbofuran 3G at the recommended dosages at the sowing time. 3. Foliar spray of Dimethoate 30 EC or Oxydemeton methyl 25 EC or Acetamiprid at the recommended dosages.
12	Leaf mosaic	Cucurbits	(Viral disease) Mosic symptom can be observed on leaf. Affected leaves become turn partially or completely yellow. Severe yield loss is observed. Vector is white fly.	1. Use disease free good quality seed from an authentic source. 2. Field should be clean and weed free. 3. Spray Acetamiprid @ 2gm/ 10 liter of water.

13	Leaf curl	Tomato, Chilli	(Viral disease) Leaves become small and curl towards the dorsal side, puckering and twisting of leaves are also observed. Dwarfing of the plant along with partial and complete sterility are also common. Virus is vectored by white fly (Bemisia tabaci), Scirtothrips dorsalis, Aphis gossypii etc.	1. Sow sorghum or pearl millet or maize as a border crop at least 60 days before transplanting. 2. Apply Carbofuran3G at the recommended dosages at the of transplanting. 3. Spray Dimethoate 30 EC at the recommended dosages at 10 days interval.(3 to4 spray)
14	Little leaf of Brinjal	Brinjal	(Mycoplasma disease) This disease is caused by mycoplasma in which there is extreme reduction of the size of the leaves and inter -nodal length giving a bushy appearance of the plant. No flowering and fruit setting takes place. This disease is transmitted by Jassids (Hishimonus phycitis)	1. Spray Dimethoate, Imidachloprid, Thiomethoxam etc. 2. Spray Tetracycline at the recommended dosages.
15	Club root	Cauliflower, Cabbage, Knol Khol	(Nematode disease) Leaves turns pale and yellowish in colour. If the plants get uprooted, swelling o f roots can be seen, roots are swollen 8 to 10 times in comparison to their normal size. Stunted growth of plants is observed. Severe loss in yield is observed.	1. Uproot the affected plant and burn the plant. 2. Apply lime so that the soil pH would become to 7.2 to 7.4. 3. Apply Carbofuran 3G to the soil before planting. 4. Apply Neem cake to the soil.

INTEGRATED NUTRIENT MANAGEMENT IN VEGTABLE CROPS

Niharendu Saha and Biswapati Mandal

With the implementation of Agri-Export Zones concept for vegetables in West Bengal, vegetables and its downstream industry have been gaining momentum recently due to globalization of market. West Bengal is blessed with all sorts of climate required for diversified vegetables cultivation. But most of the vegetables are cultivated in the highly intensified agricultural soils. Inclusion of vegetable crops, in general, hybrids, in particular, in the existing cropping systems creates problem related to soil deterioration. Such intensification of agriculture has its attendant problems of salinization, acidification, desertification, nutrient depletion, loss of soil biodiversity, soil erosion etc. In some cases, year round cultivation of vegetables with indiscriminating use of fertilizer, hormones and growth regulators, soils have become lifeless losing retentivity for nutrients as well as water. Besides, use of enormous fertilizer inputs substantially enhanced the production cost, deteriorates soil and water quality and increased the greenhouse gas effect making the production system unsustainable. In some areas yard mark for vegetables, soils is deteriorated to such extend that soil become structure less as good as talcum powder. More so, the quality of the vegetables in terms of value addition, keeping quality etc. is in questions. It has also been implicated in over-taking the resilience of agricultural soils and those natural processes that maintains its health and quality. Sometimes the stress exceeds the resilience capacity of the soil so that restoration becomes very expensive or even impossible. Since, the long-term performance of agricultural system is important for poverty alleviation and sustaining production in the face of continuous population growth, we need to redo our present way of cultivation with only inorganic fertilizer to save the natural resource base, particularly soil, for posterity.

When these environmental problems in intensive agriculture came into spotlight, organic farming was advocated as a solution for most of the problems encountered. However, the organic farming is not only a very low yielder but has many of the problems of conventional high intensive agriculture. Thus organic farming methods do not offer solution to many of the problems. To achieve sustainability in production system and maintain natural resource base in good stead, blending or integrating organic, inorganic, biological and mechanical inputs with ecological principles in mind may be an option. Through this article an attempt has been made to discuss some of the issues involved in integrated nutrient management for vegetable crops.

Nutrient requirement of vegetable crops :

Vegetables are one of the components in current cropping system under both irrigated and non-irrigated areas. Because of high return, sometimes farmers also

grow exclusively vegetables on their land year the round. This has become more common after the introduction of hybbrids cultivars for different vegetables like cabbage, cauliflower, carrot, brinjal etc. On biomass yield potentiality, they out-yield cereals and other commonly grown crops by many times. The major vegetable crops remove no way less amounts of N, P, K in comparison with other major crops. But less attention has been given to this fact. The figures given in Table 1 revealed that potato and pea removed relatively more NPK than other crops. If the total removal of nutrients by vegetables is calculate depending upon total YIelds, the figures would be higher than cereal crops. Hence, a greater emphasis need to be given to check the depletion of nutrients from soils under such vegetable crops by maintaining adequate nutrient supply. As such the major vegetable crops remove no less amounts of N, P and K than other major crops. They severely exhausted the inherent nutrient sink to support crops on sustainable basis. Moreover, vegetables are very much sensitive towards their choice of nutrients and mood of appication. Less attention has been given to the aspect of nutrient management of vegetable cultivation. Hence, greater emphasis needs to be given to check the depletion of nutrients from soils when vegetables are grown alone or in a cropping system by maintaining adequate and crop specific nutrient supply and better soil environment.

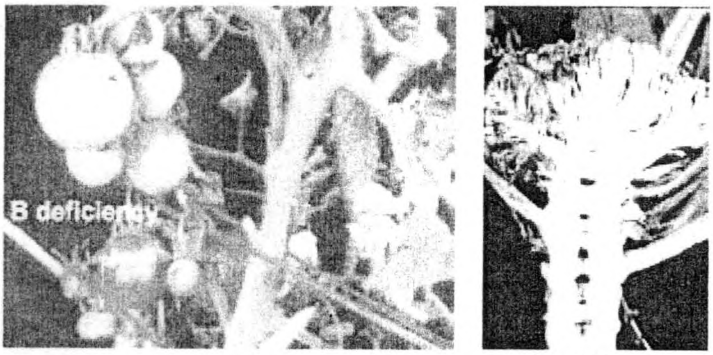
Table 1. Plant nutrients removed by various vegetable crops

Crops	Nutrient removal (kg *1100* kg yield)		
	N	P	K
Cauliflower	0.40	0.16	0.50
Onion	0.30	0.13	0.40
Pea	1.25	0.45	0.90
Potato	0.74	0.28	1.39
Pumpkin	0.15	0.16	0.16
Spinach	0.50	0.15	0.30
Tomato	0.33	0.11	0.44

Nutrient imbalance and associated symptoms in vegetable crops :

Although Vegetables remove and require good amount of nutrients from soil, knowledge about the scientific management of the nutrients and formulation of fertilizer schedule for major vegetables are lacking. Farmers apply fertilizer on either *adhoc* basis or on his own judgment This leads to imbalanced nutrition of those crops on one hand and wastage of costly fertilizer materials on the other. Imbalanced nutrition sometimes results in a net loss in value addition in vegetable crops. This sometimes creates problem in global market. Nutrient imbalances in vegetable crops visualize various forms of deficiency symptoms and encourage susceptibility to incidence of pest and diseases. To overcome this, a balanced nutrition using organic and inorganic sources of nutrients is essential. If done properly, this may also ensure not only a higher yield and less loss of costly fertilizer inputs but also maintain a good soil and ecosystem health for sustaining soil productivity.

Deficiency symptoms of micronutrients



Cauliflower for Mo deficiency

Tomatoa **Cauliflower**

Table 2. Some common deficiency symptoms associated with imbalanced nutrition

Symptom	Due to	Remedy
Root splitting in radish	High ammonium in	Soil-test based fertilizer (non-ammonical fertilizer)
Fruit cracking in tomato	Deficiency of boron	Soil application of borax @10 kg/ha with basal NPK
Whiptail of cauliflower	Deficiency of molybdenum	Spary of ammonium molybdate @250 g in 500 liter water/ha
Blossom end rot of tomato	Low pH and calcium deficiency	Soil application of lime 10-14 days before transplanting
Black rot in cabbage/ cauliflower	Disproportionately higher application of N	Application of P & K proportionately
Hollow stem and head of cabbage/cauliflower	Deficiency of Boron	Soil application of borax @10 kg/ha with basal NPK

Fertilizer guides for vegetable crops :

Field experiments, crop nutrient surveys, and grower experience have shown that vegetable crops usually respond to the application of nitrogen (N) fertilizer with increased yield, improved quality, or both. Phosphorus (P) application is also equally important for vegetable crops, especially for enhancing early seedling growth. Potassium (K) requirement is no less than either N or P, particularly for root crops which have high K requirements. Soil analyses can be used to indicate whether or not the next crop is likely to respond to K application.

The secondary plant nutrients, calcium, and magnesium, with the exception of S and all micronutrients, excepting zinc, boron and molybdenum are seldom needed for vegetable production in India. Some Indian soils are very low in available zinc and certain sensitive vegetable crops such as beans, onions, and sweet/baby com may be stunted and produce poorly unless zinc fertilizer is applied. As a general rule for best results, all P and K and part of the N fertilizer should be applied before or at planting time with remaining N applied in one or more applications following plant stand establishment. For a number of short season vegetable crops, including green beans and potatoes, a single, preplant or at-planting application of all fertilizer materials is sufficient for maximum yield and quality. Long-season vegetables, such as garlic and onions, usually benefit from split applications of nitrogen. Specific application rates within the ranges presented in Table 4 should be determined after consideration of all available information such as previous cropping records and soil analyses.

The response of fertilizer application in terms of quantity and quality parameters depends on many factors. The fertility gradiect of the field, recent cropping history and soil test value beside type of soil plays an important role in fertilizer management practices. Table 3 lists appropriate soil deficiency and sufficiency ranges for P and K for vegetable crops in Indian soil.

	Response likely		Response unlikely	
	P	K	P	K
Potato (mineral soils)	<12	<100	>25	>150
Tomato	<6	<50	>12	>80
Warm season	<5	<50	>9	>70
Cool season vegetable	<10	<50	>20	>80
Lettuce	<15	<50	>25	>80
Muskemlom	<8	<80	>12	>100
Onion	<8	<80	>12	>100

Table 4. Fertilizer guides for some vegetable crops

Crop	Fertility level								
	Low			Medium			High		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Tomato	120	60	60	100	50	50	80	40	40
Brinjal	120	60	60	100	50	50	80	40	40
Cabbage	200	60	90	150	60	80	120	60	60
Cauliflower	150	80	80	120	60	60	100	50	50
Radish	60	60	60	50	60	60	40	60	60
Okra	100	60	60	80	50	50	60	40	40
Pointed gourd	120	60	50	100	60	50	90	60	40

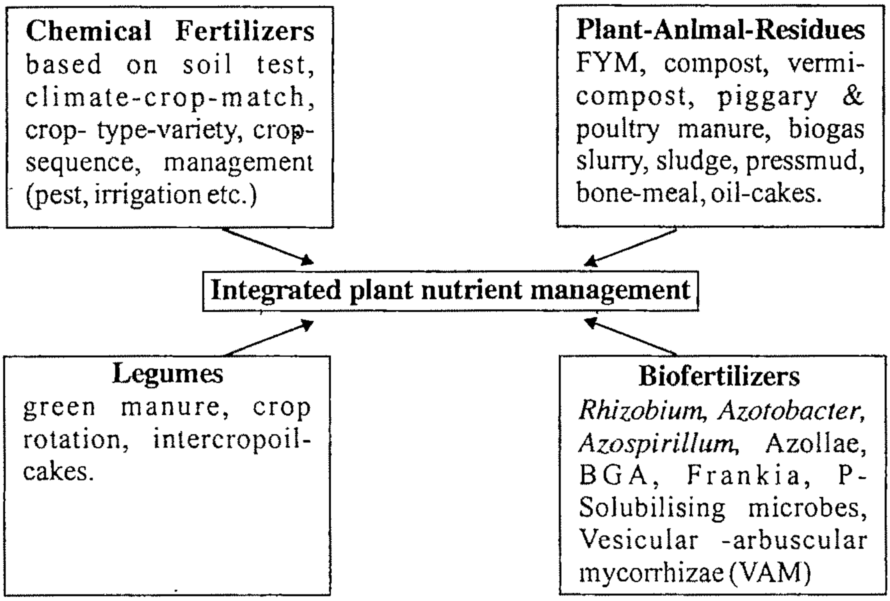
Table 5. Guide for diagnosing nutrient status (concentration in ppm) for vegetable crop production

Source: Dir. Of Ag. Govt. of WB

Components of INM :

Proper management of plant nutrients is necessary to ensure higher productivity, balanced nutrition and for checking wastage of costly fertilizer nutrients as well. Above all the quality of vegetable will be ensured. The basic concept underlying the integrated nutrient management system (INM), nevertheless, is the maintenance and possible improvement of soil fertility for sustained crop productivity on long-term basis and also to reduce fertilizer input cost and environmental degradation by employing all possibly available, accessible and affordable sources of nutrients.

A delineation of INM components



Chemical Fertilizers based on soil test, climate-crop-match, crop- type-variety, crop-sequence, management (pest, irrigation etc.)

Plant-Anlmal-Residues FYM, compost, vermi-compost, piggary & poultry manure, biogas slurry, sludge, pressmud, bone-meal, oil-cakes.

Integrated plant nutrient management

Legumes green manure, crop rotation, intercropoil-cakes.

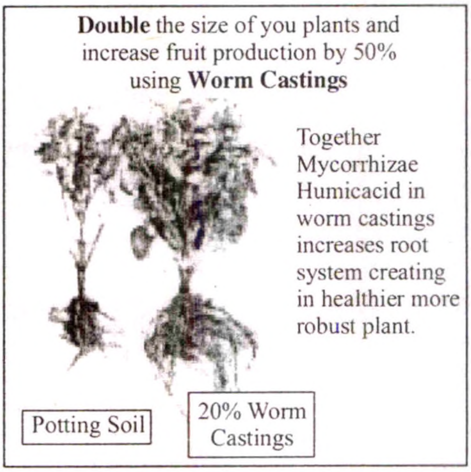
Biofertilizers *Rhizobium*, *Azotobacter*, *Azospirillum*, Azollae, BGA, Frankia, P-Solubilising microbes, Vesicular -arbuscular mycorrhizae (VAM)

Integrated nutrient management in Vegetable crops

The judicious combination of organic and inorganic resources for balanced plant nutrient management is necessary since neither inorganic fertilizer nor the organic matter alone can bridge the gap between sustaining productivity and up-keeping soil health and resilience. The organic components are indispensable in–

- improving nutrient-use-efficiency,
- improving soil aggregation, aeration and water-holding capacity,
- preventing erosion,
- encouraging microbial population vis-à-vis activity,
- accentuating nutrient mineralization, and
- amending problems like soil acidity, salinity etc.

Nevertheless such priority roles organic components play in plant nutrient management, it alone can not make the orchestra. Organic matters are generally bulky in nature and difficult to port. The availability of plant nutrient is relatively slow and cannot be managed to administer in time/crop growth-stage wise schedule. The combination of organic and inorganic sources of nutrients may be an option to overcome the problems associated with each of the sources when applied alone.



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Cultivation of vegetables are increasing day by day. Simultaneously the use of organic manures are also increasing. If the amount of chemical fertilizers used in vegetable cultivation is to be completely substituted by organic manures an astronomical figures of organic manure will be required. The recycling of that much of organic is rather impossible. Hence, for partial fulfillment and sustainable production, whatever organics are available, accessible and affordable by the farmer they must be returned to the soils along with the inorganic source of nutrients.

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Chemical fertilizer :

For normal and healthy growth, crop requires balanced supply of primary, secondary and micronutrients. The fertility status of soils and deficiency/sufficiency levels of different plant nutrients will be evaluated on the basis of soil test results and recommendation for fertilizer application will be made accordingly. Special attention should be paid on tissue test for vegetables because in some cases higher soil test value does not manifest by the leaf colour and growth of vegetable plants. This if mostly due to unavailability of that particular nutrient element. This phenomenon is primarily observed in micronutrient elements. However, application of huge amount of chemical fertilizer, particularly to meet the high nutritional demand of hybrids, may end up with soil supporting low biological activity, acidified and imbalanced availability of different nutrient elements. Moreover, the improper form of nutrient application may results in weakening of vine or stem susceptible for diseases and pest

Table 5. Fertilizer guide (%) for foliar application micronutrients

Micronutrients	Concentration in foliar application
Zinc	0.2-0.6% $ZnSO_4$+ 0.1-0.3% lime
Boron	0.5-0.6% Borax
Molybdenum	0.05% ammonium molybdate
Iron .	0.4% $FeSO_4$ + 0.2% lime
Manganese	0.4%-0.6% $MnSO_4$ + 0.2-0.3% lime
Copper	0.1-0.2% $CuSO_4$ + 0.5% lime

Foliar nutrient application where basal S, B and Zn are not added

- Vegetable farming is a high input proposition with higher returns, so any expected loss due to failure to apply basal S, B and Zn needs to be corrected.
- Plants can absorb nutrients from dilute solutions applied on to the leaves, so Zn, B and S deficiencies can be readily corrected through foliar application as described here.

(a) Foliar application of Agribor (0.1%) + Zinc sulphate ¬(0.5%) + Unslaked lime (0.25%), 2-3 times at 10-15 days interval between 30–60 days after sowing/transplanting. To make this fertilizer solution, dissolve 100 g agribor + 500 g zinc sulphate + 250 g lime in 100 litre of water (good for ½ acre).

(b) The addition of unslaked lime is needed to neutralize acidity caused by zinc sulphate ionization.

(c) The solution required for one ha is 500 litres.

(d) Optimum time of day for foliar application is early morning or early evening, because of less evaporation and longer period for absorption of nutrients through opened stomata.

Advantages of foliar nutrient application :

(a) Nutrients applied to the foliage are absorbed more rapidly than when applied to the soil.

(b) Smaller quantities of the nutrients are required than when applying to the soil.

(c) The danger of fixation and/or leaching is also reduced.

(d) It provides a convenient method of application for fertilizers required in small amounts.

(e) Urea meant for top dressing may further be split and applied along with micronutrient sprays, @ 1-2% (i.e. 1-2 kg urea/100 litre of solution) for getting higher efficiency.

Table 6. Rating chart for soil test data

Fertility level	Organic carbon Percent	Available N (kg/ha)	Available P_20_2 (kg/ha)	Available K_20 (kg/ha)
High	> 0.75	> 450	> 90	> 340
Medium	0.50-0.75	280-450	45-90	150-340
Low	< 0.50	< 280	< 45	< 150

Table 7. Soil status and fertilizer guide for secondary and micronutrients

Micro/secondary Nutrients	Critical limit (µg/g)	Fertilizer recommendation
Zinc	0.6-1.0	$ZnSo_4$ @ 25 $kg.ha^{-1}$ with organic manure
Boron	0.5	Borax @ 10 $kg.ha^{-1}$ with basal NPK
Molybdenum	0.2	Ammonium molybdate @ 1.0 $kg.ha^{-1}$ with basal NPK
Iron	2.5-4.5	$FeSO_4$ @ 50 $kg.ha^{-1}$ with organic manure
Manganese	1.0	$MnSO_4$ @ 30 $kg.ha^{-1}$ with basal NPK
Copper	0.2	$CuSO_4$ @ 5 $kg.ha^{-1}$ with basal NPK
Sulphur	10-12	Elemental S @ 25-45 $kg.ha^{-1}$

(Source: Dir. Of Agriculture, Govt. of West Bengal)

Organic resources :

CARROT(O.P.): EARLY NANTES

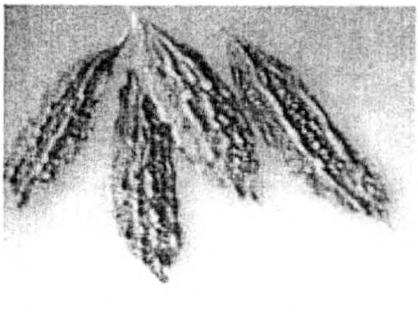
The huge nutritional demand of vegetables, in general, is difficult to meet through organic sources of nutrients. Neither it is practical to restrict nutrient management through organics. However, in many occasions it is found that combined application of mineral and organic sources have synergistic effects for increasing the fertilizer-use-efficiency of crops. The organic improves soil physical condition by improving soil aggregation, aeration and water-holding capacity of the soil and prevents erosion. Application of organic sources also triggers microbial activities, which directly reflects on the trans-formation of nutrient to easily available form (mineralization). All this inter alias, help to have higher use efficiency of fertilizer vis-à-vis native soil nutrients by the standing crops. This synergistic effects of organic and inorganic sources of nutrients may be utilized for harvesting good quality of vegetables.

Table 8. Mineral values of some commonly used organic sources

Organic manure	Nutrient Content (%)		
	N	P_2O_5	K_20
FYM	0.5-1.0	0.3-0.5	0.4-1.0
Compost (urban)	1.2-2.0	1.0	1.5
Compost (rural)	0.4-0.8	0.3-0.6	0.7-1.0
Slurry from gobar gas plant	16-1.8	1.1-2.0	0.8-1.2
Dhaincha (green manure)	0.6	-	-
Cowpea (green manure)	0.7	0.1	0.6
Mustard Cake	5.1	1.8	1 .1
Neem Cake	5.2	1.0	1.4
Groundnut Cake	7.0	1.5	1-3
Linseed Cake	5.5	1.4	1.2
Mahua Cake	2.5	0.8	1.8
Castor Cake	5.5	1.9	1.0
Sludge	2.5	1.0	0.4
Activated Sludge	4.0- 7.0	2.1-4.2	0.5-0.7
Vermi Compost	1.0	0.5	1.5

(Source: Dir. of Agriculture, Govt. of West Bengal)

Biofertilizers :



F1 HYBRID BITTERGOURD: INDAM-49

Biofertilizers are the cultures of microorganisms used for inoculating seed and soil or both under ideal condition to increase the availability of plant nutrients. They are cost-effective, eco-friendly and renewable sources of plant nutrients used to supplement chemical fertilizers in sustainable production system. Some common biofertilizers of agricultural importance for vegetable cultivation are Azotobactor, P-solubilizer and VAM. The N-fixers like Azotobacter, Azospirillum , P-solubilizers and VAM are commonly used to flower crops like gladiolus through corm inoculation (@ 2.5 kg biofertilizer dissolved in 20L water with starch/molasses for one hectare), seedling root soaking (@ 2.5 kg fertilizer dissolved in 35-40 litre of water for 30 mins soaking seedlings of one hectare) and soil application (@ 4.0 kg fertilizer + 200-250 kg organic manure for one hectare during land preparation).

Use of biological fertilizers :

Instead of sole nutrients, use of huge amounts ••of fertilizer nutrients for vegetable crops and integration of cost effective biofertilizers can contribute in enhancing the use efficiency of fertilizer management to bring in better economics or benefit/ cost ratio.

Vesicular Arbuscular Mycorrhizae (VAM) :

VAM infects roots, increases effective root ••surface and soil volume explored for nutrient uptake through extensive mycelia along with the solubilizing effect by chemicals released.

VAM culture may be applied by mixing with ••organic composts and spreading at sowing/transplanting; coating onto the seed; dipping seedlings into the VAM spore solution; or spraying on the soil around the plant and watered into the root zone.

Depending upon the number of spores in the ••VAM culture, the quantity of the culture should be adjusted in a way to apply 10 to 20 spores per individual germinating plant.

Phosphate solubilizing micro-organisms (PSM) :

PSMs can solubilise the complex insoluble ••form of phosphorus into simple soluble forms that can be taken up by plants.

For PSM application, mix the culture uniformly with the seeds by using a minimum amount of water, dry the inoculated seeds in the shade and sow immediately. If the seed is to be treated with pesticides; first • follow the pesticide treatments and finally treat seeds with PSM. For transplanted crops, mix the inoculants in a • bucket of water, stir the mixture vigorously and then dip the roots of seedlings in this mixture before transplanting.

Use 5 to 10 g culture (~109 spores per g) per kg • of seed, 1 to 2 kg for soil application per acre of land, 1 kg for root application (root dipping) of one acre of crop.

Nitrogen fixing bacteria :

The non-symbiotic group of bacteria • *(Azotobacter/Azospirillum)* in non-leguminous, while symbiotic *(Rhizobium)* in leguminous vegetables may be used to fix the atmospheric nitrogen and make it available to plants.

For inoculating N-fixing bacteria, mix the culture • uniformly with the seeds by using a minimum amount of water, dry the inoculated seeds in the shade and sow immediately.

For transplanted crops, mix the inoculants in a • bucket of water, stir the mixture vigorously and then dip the roots of seedlings in this mixture before transplanting. Use 15 to 20 gm culture (~109 spores per g) per • kg of seed, 1 to 2 kg for soil application per acre of land, 1 kg for root application (root dipping) one acre of crop.

INM in nursery raising :

- To harvest good productivity in vegetables (tomato, chillies, brinjal, onion etc.), which are first raised in nursery and then transplanted, it is very important to raise healthy seedlings by following INM as described below :
  (a) Apply 4-5 kg vermicompost (Fig. 5) and 100 g 12:32:16 (N:P:K) fertilizer or equivalent nutrients fertilizer in a bed measuring 3 m (long) × 1 m (wide).
  (b) Spray seedlings with 0.2% urea + 0.05% agribor + 0.2% zinc sulphate + 0.1% unslaked lime when plants are of 8 -10 cm height (2-3 weeks)

Value addition through Integrated Nutrient management :

Integrated Nutrient management not only ensure good harvest on sustainable basis but also improve vegetable quality by enriching some biologically active substances so called antioxidants viz, carotene, lycopene, vitamic C, crude fiber anthocyanin etc. in produce. Only chemical fertilizers fail to trigger the plant physiology to synthesis those molecule in larger scale. Chemical fertilizer in conjunction with organics improve the concentration of those substances and their by improve quality of vegetable. Here a case study is illustrated with cauliflower as test crop.

Table 9. Value addition in vegetables through nutrient management and their relative advantage – a case study on cauliflower

Treatment	Yield (q ha^{-1})	Dietary fibre (%)	Crube protein (%)
Control	99.0	41.7	10.3
FYM	129.0	20.0	11.4
VC	116.0	18.0	15.8
T2	327.0	42.0	19.8
VC+T2	346.0	51.0	19.8

FYM @20t ha^{-1}, VC @10t ha^{-1}, T2@ 250-125-125, VC+T_2= VC@ 3t ha^{-1}1+T_2

Conclusion :

With the health consciousness of the consumers vegetable business is an upcoming non-conventional global business. With the increasing demand both in domestic as well as foreign market, its status in Indian economy also gaining escalation. But undoubtedly, it faces some serious problems associated with quality product; in general, pesticide residue and heavy metal content, in particular, are serious threat in global market. So, it is imperative to initiate technological intervention to improve the quality of vegetable in one hand and improvisation of vegetable quality in other hand. Nutrient integration is an appropriate technology that can bridge the both end and can help the industry to survive.

PROTECTED CULTIVATION OF CAPSICUM (*CAPSICUM ANNUM L*)

Dr. T. K. Chowdhuri and Dr. S. Das

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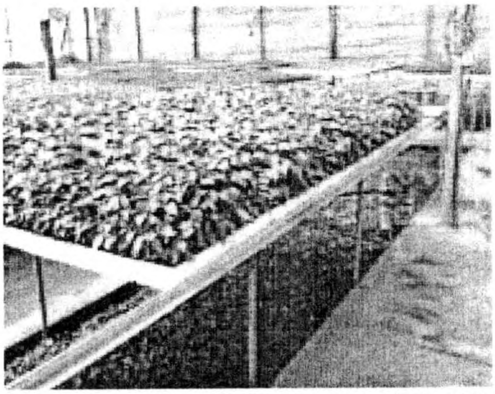
Capsicum is one of the most important vegetable crops growing in the world in temperate regions contributed annual production is near about 30 million metric tones from 2 million hactors of land. Among the capsicum producing countries in the world China is sharing 36% (9.72mmt.) of the world produce, where as very negligible performance found in India in terms of area, production and productivity (production 1.0 mmt, area 1.0 mha, productivity 1.0 tonnes/ha), but there is a huge scope of cultivation of capsicum in future in all over India. It has been found that it grow very well in temperate region through out the year, except winter season, but in tropical and subtropical region it can be successfully cultivated during winter to summer under natural ventilated green house or 35% shade house. The details of agro-techniques are summarized below for the benefit of the enterprises to take a challenge for commercial cultivation.

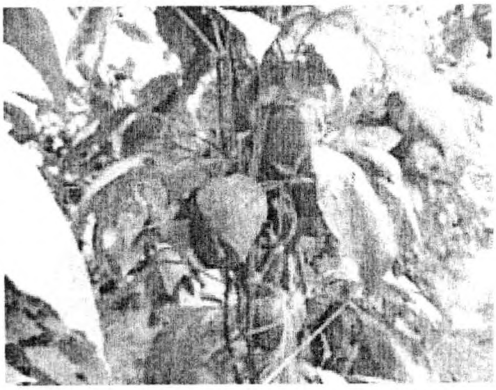
1. **Climatic condition :** Capsicum favour temperate regions, where temperature prevails 15-25^{0}C, dry weather and 8-10 hrs photo periods. Presently, its growing very well in tropical and subtropical region in winter under natural ventilated green and shade house and cultivation time can be extended up to summer season also. During nursery management, temperature of micro-climate to be maintained 18-27^{0}C for good seed germination, whereas at the flowering to fruit setting stage temperature ranging 10-15^{0}C is best. CO_2 concentration increased up to 1500-1600ppm under green house improve yield of the capsicum in term of fruits quality and quantity.
2. **Growing media :** Capsicum is high value vegetable crops and its require balance nutrient content growing media. The best suitable ingredients are used like sandy loam soil + FYM + Cocopeat + Sand in the ratio of 2:1:1:1 along with Vermicompost @ 2kg/sqmt. Sometimes the growing media is also enriched with addition of neem cake and bone meal @ 100 gm/sqmt of each. After mixing of all ingredients of the growing media developed a raised bed up to 15 cm height by maintain of 100cm width and length of the beds depends on the size of the green house. Among the beds a space to be kept 50 cm between two bed for operational works. For controlling soil born diseases, the growing media should treated with 2% formaldehyde followed by black poly-mulching for a week. When bed is ready for plantation then a pipe line should place all over the beds with dropper for drip irrigation with liquid fertigation. The beds were mulched with 30 micron thickness silver colour polythene and then some holes to be made on the polythene at an interval of 60 and 45 cm row to row and plant to plant respectively.

3. **Seedlings raising :** Healthy seedlings with well established root system of capsicum seedlings to be raised under polyhouse or poly tunnel in pocket tray seed beds. Here, tray is made by the use of polypropylene, where uniform size of 98 pockets is made and each pocket has one hole in the bottom for drainage of water. The size of the pockets for rising of capsicum seedlings will be 2.5cm. The growing media used for raising of seedlings is cocopeat and vermicompost (1:1). The best time for seed sowing of capsicum is June to July (Kharif), September to October (Rabi) and January to February (Summer), near about 500-550gm seed is required for one hectore of area cultivation.



4. **Planting :** The 40-45 days old seedlings (12-15cm height) are used for transplanting in the raised bed. During planting, plant to plant and row to row spacing to be maintained 45 and 60cm respectively. The best time of planting is in the evening followed by watering.

5. **Application of nutrients and growth regulators :** Generally, liquid feeding is an ideal for proper vegetative and reproductive growth of capsicum. In this aspect, water soluble fertilizers of N: P: K (1:2:0.5) should applied through drip irrigation regularly up to 45 days after transplanting and N:P:K (2:1:3) fertilizers should feeding at an interval of alternate day up to harvesting. Bio-fertilizer like *Azospirillum* @ 5kg/ha improved yield of capsicum. NAA, GA3 and Paclobutrazol at the rate of 10, 100 and 150 ppm on foliar spraying increased capsicum yield.



6. **Irrigation and Intercultural operation :** Misting irrigation is beneficial for the growth of capsicum plant, but it should stop just before flowering stage. Drip irrigation one hour in a day through dripper at the evening is recommended. Try to growing media kept moist, but water stagnation in the beds helps to the plants die-back. After one month of transplanting, at least one pinching should done for forcing of branch initiation and four number of branches per plant is ideal for better fruiting. The leaves turned yellow and weak branches are removed periodically.

7. **Plant protection :** Under green house cultivation of capsicum, plants were badly affected by several insects as well as diseases and any time plant become collapse, resulted to stop vegetative and reproductive growth. So, regular observation can be taken under consideration from starting to crop termination. Some problems related to diseases occurance recorded at regular intervals found under green house like powdery mildew (control by foliar spraying of Penconazol 10EC @ 0.05%), Die-back (control by foliar spraying of Propiconazole 25EC @ 0.1%), fruits rot may be control by application of Metaloxyl (8%) along with Mancozeb 72 WP(64%) and Sclerotium rot (control by foliar spraying of Carboxin 75WP@ 0.2%). Similarly, some major insects are created a problems in green house namely Thrips(control: Imidacloprid 17SC @) 0.05%), Mites (Abamectin 1.9EC @ 0.03%) and Fruits borer (Control: Methomyl 40SP @ 0.2%).
8. **Harvesting and yield :** When green fruits started to change colour breaking from green to silver, green to yellow, green to red etc. after 80 days of planting showed fruits are ready to harvest and continued to harvest up to 80 days till plant terminate. The implements used for capsicum harvest is secateurs. After harvesting of fruits are shorting, cleaning and grading for packaging in corrugated card board for transportation in distance market. It has been found that 15-20 number of fruits can be obtained per plant, where each fruits weight can be expected 150-200gm. An average yield per plant was recorded 2-2.5kg, where 400-450 quintal/ha capsicum fruits vegetables can be easily get with application of proper agro-techniques
9. **Varieties :** The most suitable commercial varieties are identified for green house cultivation are Arka Mohini, Arka Gaurav, Arka Basant, Bharat, California Wonder, Heera, Indra, Orobella, Pusa Deepati, Sarpan F-1 Hybrid and Yolo Wonder.

Conclusion:

Capsicum is one of the most important vegetable crops growing in the world in temperate regions. There is a huge scope of cultivation of capsicum in future in all over India. It has been found that it grow very well in temperate region throughout the year, except winter season, but in tropical and subtropical region it can be successfully cultivated during winter to summer under natural ventilated green house or 35% shade house. The suitable agro-techniques can benefit the enterprises to take a challenge for commercial cultivation.

PROTECTED AND PRECISION VEGETABLE FARMING IN THE PLAINS OF WEST BENGAL

P. Hazra and M. K. Samanta

Precision farming :

Precision Agriculture and Horticulture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving production and environmental quality. The success in precision agriculture depends on the accurate assessment of the variability, its management and evaluation in space-time continuum in crop production. The agronomic feasibility of precision agriculture and Horticulture has been intuitive, depending largely on the application of traditional arrangement recommendations at finer scales.

We are aware that several developmental projects related to some aspects of "Precision farming" are being handled in the Department of Food Processing Industries and Horticulture, Government of West Bengal. Intensive training on several steps in "precision farming" including protected farming, siphon irrigation; drip, micro-sprinkler irrigation, plant nutrition based on tissue nutrient analysis, fertilizer placement in the root zone; mechanical and chemical control of weeds; integrated pest management, etc. is essential to boost up the technology adoption in this respect.

Benefits of precision farming :

1. It not only boosts the production but also the morale of the farmers.
2. Vegetables have increased uniform size, high quality and extended shelf life.
3. The crops have increased duration to tackle the demand and supply position.
4. Reduction of inputs for farming and increase in nutrient and water use efficiency.
5. Reduction in cost of production.
6. Cost of labour is minimized due to use of drip and fertigation.
7. Market knowledge to the farmers.
8. Enrichment of microbial status of the soil.

Working plan for initiation of protected vegetable farming venture

- Development of "Precision farming centre" for demonstration and accomplishment of the technology to the farming community.
- Development of potential farmers' cluster for protected and precision farming.
- Specific training programmes for the farmers of the cluster.
- Utilization of scientific nursery technologies to produce healthy and virus

free seedlings in a community basis.

- Use of drip irrigation system to ensure maximum irrigation efficiency and reduce water usage.
- Fertigation with water soluble fertilizers to increase nutrient use efficiency.
- Usage of proper technologies like, soil and plant tissue analyses to assess soil fertility status in the field and nutrient status of the plant.
- Integrated nutrient and crop protection practices.
- Development of market channel.

The farmers are to be sensitized on the market forces and reorient the production system as a whole to respond to the market. Concept of precision farming is to be implemented through participatory and demonstrative farming by the selected vegetable and spice growers of Central sector Vegetable Initiative scheme. They will be provided with precision farming technologies in production and make them understand the conservation of Natural resources, input management and food safety issues, which in turn helps to generate, produces acceptable to international consumers., there by getting linked to the market. The basic objectives of the precision farming can be placed into two broad categories:

1. Promoting hi-tech horticulture through the use of precision technology that involved successfully transferring the latest cultivation and post-harvest technologies to the farmers
2. Promoting market-led horticulture by encouraging farmer's forums and associations and increasing the overall value accruing to the farmers.

Different considerations of protected cultivation of vegetables :

Production for domestic market

(a) Production system for local market characterized by small area (1-2 ha), too many varieties and intensive nature of cultivation. b. Production system for interstate market (internal export) characterized by larger horticultural estates, one or two specific varieties and extensive nature of cultivation.

Production for export

(a) Production system for export of raw produces involving Good Agricultural Practices, organically certified production, Precision farming, etc with total concern for consumer's preference of the importing countries. b) Production system for export of value added products to developed countries, duly following the prescribed sanitary and phytosanitary standards, permissible limit of pesticides, ensuring 100 per cent food safety. The precision farming project is an effort to strengthen the production systems for export in general and raw produces in particular.

Remote sensing technology :

Making use of the GIS, the concept of developing physiographic map, soil map, and land use map will be developed. The remote sensing programme enabled the scientists to exactly locate the actual field to scale map its boundary. The data on N,P,K, Ca, Mg, Mn, Fe and Cu will be collected and variability for the field and in field variability will be assessed. This will enable the scientists to precisely apply the required nutrient in accurate quantities to the root zone during critical phases of crop growth.

Chisel ploughing :

The chisel plough technology ensures better aeration to root zone and effective drainage during rainy days. Further it will help the plants to develop root system with characteristically uniformity in pattern, architecture and in adequate mass. The Chisel plough needs to be operated once in two years.

Hi-Tech Community Nursery :

The seedlings will raised in portrays under net/shade/poly houses with insect proof netting making use of EC and pH adjusted coco peat or other suitable media treated with pseudomonas. The seedlings produced will be strikingly uniform with similar physical and physiological age thus ensuring 100 per cent field stand and sustained 100 per cent productive plants. The root mass will be on the outer surface of root ball and hence there will be no causality.

Variability of soil water and its implication on precision farming :

Soil water content patters have profound implication for precision horticulture in general, and water management in particular will be assessed for several vegetable crops grown in different systems viz., open, under mulch, under poly house, under shade net house and under simple net house.

Measuring Nutrients to optimize fertilizer efficiency and protect environmental Quality :

Plant tissue analysis shows the nutrient status of plants at the time of sampling. This, in turn, shows whether soil nutrient supplies are adequate. In addition, plant tissue analysis will detect unseen deficiencies and may confirm visual symptoms of deficiencies. Toxic levels also may be detected. Though usually used as a diagnostic tool for future correction of nutrient problems, plant tissue analysis from young plants will allow a corrective fertilizer application that same season.

Not all abnormal appearances are due to a deficiency. Some may be due to too much of certain elements. Also, symptoms of one deficiency may look like those of another. A plant tissue analysis can pinpoint the cause, if it is nutritional. A plant analysis is of little value if the plants come from fields that are infested with weeds, insects, disease organisms; if the plants are stressed for moisture; or if plants have some mechanical injury.

The most important use of plant analysis is as a monitoring tool for determining the adequacy of current fertilization practices. Sampling a crop periodically during the season or once each year provides a record of its nutrient content that can be used through the growing season or from year to year. With soil test information and a plant analysis report, a producer can closely tailor fertilization practices to specific soil-plant needs.

It also may be possible to prevent nutrient stress in a crop if the plant analysis indicates a potential problem developing early in the season. Corrective measures can be applied during the season or, if the crop is perennial, during the next year. Combined with data from a soil analysis, a tissue analysis is an important tool in determining nutrient requirements of a crop. By request, the following elements can be determined in a plant sample:

Soil testing and plant tissue analysis are similar in that they both measure nutrients necessary

for plant growth. Soil tests are most useful before planting to predict lime and fertilizer needs; tissue tests are best used during the growing season to monitor plant nutrient uptake. When growth problems occur, both tests are necessary to provide a complete diagnosis of a crop's nutritional status and the best corrective action. Soil tests measure levels of specific nutrients in a soil. They cannot indicate whether plants growing in that soil are able to take up the nutrients. Soil tests are also not reliable indicators of nitrogen and sulfur (which leach readily from the soil) or iron and boron. They are, however, the best way to assess soil pH. Plant tissue analysis indicates whether adequate concentrations of essential plant nutrients are present at the time of sampling. Alone, it does not provide enough information to explain why nutrient levels may be high or low. In combination, however, soil test and plant analysis results often reveal the reason.

Integrated plant nutrient management system (IPNS) :

The integrated plant nutrient system (IPNS) includes the balanced use of chemical fertilizers; organic manures and biofertilizers which not only increase the productivity in sustainable manner but also takes care the soil health and productivity. The IPNS system is more result oriented in protected vegetable cultivation where crop rotation and soil replacement is a highly difficult task. It will be more effective and sustainable if both IPNS and IPM systems are adopted together.

Integrated pest management (IPM) :

It is the eco-friendly system approach in both strategies and technologies to reduce the dependence of chemicals for controlling the pest and diseases. Nevertheless, multiple support and co-operation from public and private organizations is needed to harness full potential of available technologies and strategies. Use of resistant/ tolerant varieties

1. Promoting awareness among the farmers about the predisposing factors for the occurrence of disease and pests and at the same time harmful effects of indiscriminate use of chemical pesticides.
2. Emphasis on the development of behavioural and cultural management

practices, use of sex pheromone, trap crop, predators, parasitoids and entomo-pathogens based management tactics to control pest and diseases.

3. Incorporation of botanicals, microbials and pheromones in IPM schedule to reduce dependency on chemical insecticides.
4. Emphasis on the quality control for the production of bioagents and botanicals and development of bioagent release technique to improve the performance of bioagents.
5. Policy frame work for proper monitoring of the quality of commercially available bio-control agents as well as products starting from production unit till its delivery to the farmers.
6. Development of awareness among the farmers regarding reduction of pesticides in farming

Development of Plant health clinic :

With the shrinking land resources, more intensive crop husbandry and even more complex agri-horticultural production and marketing systems, the agro-biologists do face newer and intricate problems in combating different biotic stresses caused by fungi, bacteria, virus, insect pests, nematodes, rodents, weeds and abiotic stresses caused by nutrient dificiency, soil reaction, high temperature and high moisture condition. It is must now to understand these stress factors, their mode of action and preventive measures with greater precision and vigour with strong laboratory support. Plant health clinic is district or specific production zone level laboratory based and service oriented project for the growers and other stake holders to elevate their skill and operative standards to produce high quality and safe product throgh Good Agricultural Practice.

Drip and Fertigation System :

Drip and fertigation system of the project ensured water economy, precise application of water-soluble fertilizers to root zone and kept an ideal moisture regime of 60 percent. In conventional system, immediately after irrigation, the air gradient of soil becomes zero and moisture gradient becomes 100 per cent. Before irrigation the gradients are reversed thus exerting stress over the root zone. In fertigated fields, the moisture regime was 60 per cent and air gradient was 40 per cent. Thus the growth became unchecked from seedling to harvest.

Protected farming :

During the past decade or so, West Bengal has been witnessing change in cropping pattern in which the fraction of total cropped area occupied by different vegetable and fruit crops have been increasing steadily. This change in cropping pattern may be considered as a step forward towards commercialization of farming from subsistence level. Rapid urbanization and sprawling of Kolkata urban agglomeration area with increased hotel business have created lot of demand for different high value/lesser known vegetable and fruit crops like, coloured capsicum, green capsicum, celery, lettuce, leek, broccoli, strawberry, etc. Continuously increasing per capita income in the urban sector has given a fillip to the growth of capital intensive diversification of agriculture.

Different components and aspects for protected farming :

- Different types of polyhouse (High cost, medium cost, low cost and bamboo polyhouse)
- Poly tunnels
- Shade net
- Net house
- Mulching
- Drip irrigation system
- Fertigation system
- Plant tissue nutrient analysis
- Soil analysis
- Post-harvest handling and packaging

Usage of protected cultivation and precision farming :

- Production of high quality vegetables of different kind and fruits like strawberry.
- Off season Vegetable cultivation
- Export oriented vegetable cultivation and floriculture
- Production of high quality and disease-free seedling and Planting material
- Hardening of tissue cultured plant
- Production of open-pollinated and hybrid seeds of some vegetables like capsicum.

Development of market intelligence and Market support :

The market situations (domestic, inter-state, export) and supply chain of vegetables will be studied and the farmers will be guided to select crop and variety for cultivation during particular season, thus making the production **market-led production** in real sense. The farmers will be provided with plastic crates and trained sufficiently on grading and sorting to different markets.

Empowerment of Farmers and Farmers' Forum :

The beneficiary farmers' will be organized under various commodity Forums of Precision Farming. The organizations will be registered under societies act and they were imparted skills to develop awareness on latest state of art technologies. The Forum will help the farmers to buy the inputs directly from the manufacturers cutting the cost down to minimum and strengthened their bargaining power while selling their produce.

Insurance cover :

The Farmers' Forum and the Crop Insurance officials meeting will be organized and eventually, the insurance cover will be extended to the crop with a low premium of 4 per cent.

Market tie-ups :

Market tie ups for the crops raised will be negotiated between the Farmer's Forum and the buyers like M/s. Metro Cash & Carry, Bharti Telecom, Reliance Fresh, Safal, etc. for buy back tie up.

Promotion of brand value :

Awareness among "The Precision Farmers' Association" so that they may develop a 'logo' and brand of their own and in each crate, the logo was pasted. The logo is now gaining popularity with the buyers offering higher rate for crates with such logo.

Post Harvest management :

The farmers will be sensitised on post-harvest operation like sorting grading, packing and marketing so that they may realize better market prices for their quality produce. They will be given training to switch over from ordinary packing to quality packing, use of gunny bags to use of plastic crates. Thus, the farmer will be trained to become agri-entrepreneurs from the level of agriculturalists.

GENETIC IMPROVEMENT OF CROP PLANTS

Subhankar Roy Barman

Introduction :

The human species emerged on this earth about 300,000 years ago. Since then to satisfy our needs we have been working for our well-being and improvement of food quality, quantity, shelter etc., without thinking of the nature and the mother earth, only to satisfy our needs. Human activities have caused enormous changes in physical, chemical, geological, biological and atmospheric realm of our planet. Genetic improvement of crop plants is not new; we have been modifying plant genomes for thousands of years now. The major crop species were domesticated about 5,000 to 10,000 years ago. This has connection to human civilisation of which development is intricately linked to agricultural growth. The biggest challenge even today is to produce sufficient amount of food for the exploding population on earth. In 1800, the world population was 1 billion people whereas in 1900, at the beginning of the 20th century, the population increased to 1.65 billion people and by 2000, that number increased to over 6 billion (http://www.plantcell.org/site/teachingtools/teaching.xhtml). The world human population is to reach 9 billion by the year 2050 and we need to at least double crop production, especially rice, by this time (Sheehy and Mitchell, 2011). Crop plants are under continuous threat by various biotic and abiotic stresses. Therefore, a continuous effort is to be exercised to ensure tomorrow's food security which is not endorsed by today's food sufficiency. We are still caught up with limited success of cultural practices, environmentally unhealthy use of pesticides and decreasing arable land area. Modern tools of plant biotechnology can complement conventional plant breeding in an economically useful way to genetically improve crop plants. In genetically modified (GM) crop plants, their genetic material is engineered using tools of genetic engineering such as recombinant DNA technology. In this approach different DNA fragments from useful sources are put together to create a new molecule that is introduced into the plant genome for desired purposes. Thus, essentially transgenic plants are those plants containing DNA from other organisms. Remarkably, while developing transgenic plants the genetic engineer enjoys advantage of cross-species gene transfer and considerable reduction in time toward generating an improved transgenic line for a specific crop plant. In the distant and recent past we have relied on domestication of crop plants, development of hybrid seeds and experienced "green revolution" through advances in plant breeding technologies. In recentyears, we are waiting for a "gene revolution" to take place through remarkable advances made in the field of plant biotechnology.

Genetic modification of crop plants :

Genetic modification can probably be defined in two ways: (i) broadly, it is development of any organism by means of breeding and selection. (ii) It can be narrowly defined as organisms developed by using gene transfer technologies. Genetic engineering involves cloning of desired genes, development of designer gene constructs and transfer of transgenes to the organism concerned. Specific changes are introduced in the genome of crop plants using the tools of genetic engineering. Till date a large number of transgenic plants have been developed across different classes of crops with various improved agronomic characteristics. Some of the remarkable examples include transgenic soybean (Reddy, 2001), corn (Lundquist and Walters, 1996), sugarbeet (Mannerlof *et al.*, 1997) plants resistant to glyphosate or glufosinate herbicide, cotton plants resistant to boll worm due to transgenic expression of *Bacillus thuringiensis* crystal proteins (Perlak *et al.*, 1990), tomato plants enabling antisense expression of polygalacturonase (Smith et al., 1988), golden rice containing ^{2}-carotene (Ye *et al.*, 2000), rice plants expressing glucose oxidase with increased resistance to both, bacterial and fungal pathogens (Kachroo *et al.*, 2003), wheat plants expressing a nonspecific lipid transfer protein which were resistant to powdery mildew and Karnal bunt (Roy-Barman *et al.*, 2006). However, so far, only a few of them have made their way to the field. Some of the crop plants that are being grown in the field are cotton, corn, soybean, canola, sugarbeet, papaya, alfalfa, tomato etc.

Benefits of GM crops

Genetic modification provides with a faster approach of qualitative and quantitative improvement of crop plants. The technology has the ability to achieve desired changes within a few generations. It allows greater precision in selecting a specific characteristic feature that requires alteration and reduces risk of random occurrence of undesirable traits. GM crops can have enhanced resistance to biotic stresses and tolerance to abiotic stresses, and improved nutritional quality. Genetic modification can allow crops to grow in previously inhospitable environments such as under conditions of drought, salinity and extremes of temperature. Some GM crops require "zero-tillage' and thus, offer a special advantage to the soil. Taken together, GM crops are developed with a goal to significantly increase crop productivity.

Concerns relating to GM crops

GM crops are subjected to various assessments to evaluate risk to human health such as allergenicity, toxicity, risks to non-target pathogens or pests, risks for movement of transgenes etc. before their release into the environment. Pollens have the ability to cross-transfer the transgenic DNA between plants. GM crops have to be grown by maintaining prescribed distances between related species to minimise this possibility. Some are concerned whether GM crops will take choice of the small farmers away and exploit them? To address this concern public-private partnerships are required to be built up to develop seeds suited for local needs. And, one of the most important concerns is whether GM crops are safe to be eaten up. All GM plants are subject to extensive testing and regulations and, so far, no detrimental health effects have been identified. GM biofortification can ensure that every child can have sufficient levels of vitamins, proteins and minerals. However, genetic modification is a beneficial tool to ensure sustainable crop production. Scientists worldwide have endorsed that genetic modification is an important tool for molecular plant breeding.

Bt Brinjal – tale of a plant producing eggs! :

Bt-Brinjal (Kumar et al., 1998; Innercone et al., 1997) has generated a lot of debate in India. Apparently, there is no difference in the agronomic parameters between Bt-Brinjal and Non-Bt-Brinjal. Although it is expected that Bt Brinjal will be beneficial to small farmers since it is resistant to insect, giving more yield without any impact on the environment, there are concerns about possible adverse effects on human health and bio-safety and diversity (Centre for Environment Education, Ministry of Environment and Forests, Govt. of India). Brinjal production suffers from tremendous loss due to fruit and shoot borer, even though 60% plant protection cost goes in controlling the borer. Many sprays of the pesticides are applied and there is lack of natural resistance to this insect pest in brinjal. Cultivation cost can be reduced by 80% if Bt-Brinjal is used. It is also claimed that there would be no threat to wild brinjal germplasm since cultivated variety does not cross naturally. Rigorous biosafety tests have been done for Bt-Brinjal and is considered safe for human consumption and environment. Yield of Bt-Brinjal is remarkably high and damage to this crop has been found to be lesser than the non-Bt-Brinjal due to the borer (Centre for Environment Education, Ministry of Environment and Forests, Govt. of India).

Genetic modification of model monocot rice :

Integrated Pest Management (IPM) practices are considered as most effective ways of controlling fungal pathogens and insect pests. IPM practices include various husbandry techniques such as cultural practices, use of agrochemicals and breeding for resistant cultivars. Although plant breeders have tried to keep pace with the growing demand for food grain production, the time-consuming and labour-intensive procedures have always limited its growth. A combination of plant breeding and plant biotechnology is required to keep pace with expanding human population and emergence of newer races of rice blast fungus (*Magnaporthe oryzae*). Plant genetic engineering allows introduction of any foreign gene(s) from even a distant species into the plant system and develop transgenic plants in a reasonable period of time. Here we review advances made in utilizing a range of cloned genes to enhance blast disease resistance in transgenic rice plants. Several other reviews on the subject of genetic engineering of fungal disease resistance provide related information on this topic (Kawata *et* al., 2003; Giri *et al., 1992;* Ayeliff and Laguda, 2004; Stuiver and Custer, 2001; Punja, 2001; Punja, 2006). The approaches that have been taken up by scientists around the globe are as follows: (1) Exploitation of components of plant disease resistance pathways. (2) Exploitation of transgenes that directly encode anti-fungal activities. (3) Exploitation of genes from microbes that can elicit defense response.

(4) Exploitation of effective non-defense-related genes. (5) Engineering lipid metabolism of plants.

Exploitation of components of plant disease resistance pathway :

(1) ***Use of cloned blast resistance genes*** : Plant *R* genes encode key proteins of disease resistance pathway that fall into at least six classes (Dangle and Jones, 2001). There are enough possibilities for development of transgenic rice plants for enhanced blast disease resistance. Most of these genes confer race-specific resistance in a gene-for-gene way and thus, will be effective against one or a few related races or strains of the pathogen. For example, transgenic rice plants expressing *Pi-d2* and *Pi-d3* were generated (Hao *et al.*, 2009). Transgenic rice plants expressing *Pi-d2* show race-specific resistance to *M. oryzae* strain ZB15. *Pi-d2* is a plasma membrane protein. It is a receptor like protein kinase with predicted extracellular domain of a bulb type mannose-specific binding lectin (B-lectin) and intracellular serine-threonine kinase domain (Chen *et al.*, 2006). A broad spectrum disease resistance gene encoding putative receptor-like cytoplasmic kinase was over-expressed in rice. The resultant transgenic rice lines were highly resistant to *Xanthomonas oryzae* p.v. *oryzae* and *M. oryzae* (Dubouzet *et al.*, 2011).

(2) ***Use of genes encoding pathogenesis-related (PR) proteins*** : PR proteins that exhibit antifungal activity have been engineered into rice. Rice class I chitinase genes (*cht-2/cht-3*) were constitutively expressed in the host plant and resultant transgenic rice showed significantly higher resistance against *M. oryzae* (Nishizawa, 1999). Bacterial chitinase was also expressed in rice under the control of signal sequence from rice chitinase gene and enhanced resistance against blast was achieved (Itoh *et al.* 2003). Fungal cell wall degrading enzymes (chitinase/glucanase) were used singly and in all possible combinations to genetically transform rice plants. Resistance to *M. oryzae* was found in all kinds of regenerated plants (Mei *et al.*, 2004). This is one of the reports of expression of multiple genes that resulted in resistance to blast and sheath blight. The *Gns1* gene of rice encodes 1,3;1,4-β glucanase which hydrolyses 1,3;1,4-β-glucosidic linkages on 1,3;1,4-β-glucan, an important component of cell walls in the poaceae family. Transgenic rice plants constitutively expressing *Gns1* genes showed stunted growth and impaired root formation. When transgenic rice plants were inoculated with virulent *M. oryzae*, they developed many resistant-type lesions on the inoculated leaf accompanying earlier activation of defense-related genes *PR1* and *PBZ1*.

(3) ***Expression of key signaling components to induce host defense response pathway*** : Initial recognition of pathogen attack can activate defense response through signaling molecules. Efforts have been made to express some key signaling components of defense response in transgenic rice.

Oxidative burst, mediated by hydrogen peroxide (H_2O_2), has been recognized as a key component of plant defense response during incompatible interaction. Transgenic rice plants expressing a fungal glucose oxidase (*gox*) were generated using both constitutive and inducible expression systems, both of which led to an increase in endogenous levels of H_2O_2, which in turn caused cell death. Elevated levels of H_2O_2 led to activation of several defense genes and these transgenic plants were shown to have enhanced resistance to bacterial and fungal pathogens (Kachroo *et al.*, 2003). Transgenic rice over-expressing *OsCDR1* (rice aspartate protease) showed enhanced resistance against bacterial and fungal pathogens including *M. oryzae*. Disease resistance in these plants was correlated with induction of *PR* gene expression (Prasad *et al.*, 2009). Disease resistance pathway similar to *Arabidopsis* NPR1-mediated signaling pathway has been described. Constitutive expression of *AtNPR1* in rice conferred resistance against bacterial and fungal pathogens including *M. oryzae*. Protection against fungal pathogens was primed by expression of salicylic acid (SA) responsive genes such as *PR1b, TLP (PR5), PR10, PBZ1*. However, over-expression of *AtNPR1* negatively regulated resistance to viral pathogens and tolerance to salt and drought stress (Quilis *et al.*, 2008). Jasmonic acid (JA) and methyl jasmonate are important signal molecules involved in induced resistance to pathogen infection and insect herbivory. Expression of *OsAOS2* (allene oxide synthase), a key enzyme in JA biosynthetic pathway exhibited enhanced resistance to blast and activation of *PR* genes such as *PR1a, PR3* and *PR5* (Mei *ei al.*, 2006). Constitutive expression of the defense-related *Rir1b* in transgenic rice plants conferred enhanced resistance to *M. oryzae* (Schaffrath *ei aL*, 2000).

(4) ***Use of defense-related transcription factors (TFs)*** **:** WRKY transcription factors have several regulatory roles in response to biotic and abiotic stresses. *OsWRKY31* is induced by *M. oryzae* and auxin. Transgenic rice plants over-expressing *OsWRKY31* was found to enhance resistance against *M. oryzae*. These lines also showed constitutive expression of several defense-related genes such as *PBZ1, OsSci2* and auxin-responsive genes like *OsIAA* and *OsCrl1* (Zhang *et al.*, 2008). Enhanced blast resistance has been obtained in transgenic rice plants expressing *WRKY45* which mediates defense signalling (Shimono *et al.*, 2007). Tobacco osmotin protein binding protein (OPBP1) over-expression led to enhanced resistance to infection of *M. oryzae*. Gene expression analysis indicated mRNA accumulation of several stress-related genes in transgenic rice (Chen and Guo, 2008).

Exploitation of transgenes that directly encode anti-fungal activity :

Antimicrobial non-specific-lipid transfer protein (ns-LTP) *Ace*-AMP1 was expressed in rice under both, inducible and constitutive promoters to be secreted in the apoplastic space. A broad spectrum of resistance against *M. oryzae*, *Rhizoctonia solani* and *X. oryzae p.v. oryzae* was observed (Patkar and Chattoo, 2006). Puroindolines, a class of antimicrobial peptides, are endosperm-specific proteins involved in wheat hardness. Transgenic rice plants expressing puroindoline genes *pinA* and/or *pinB* showed significantly increased resistance to *M. oryzae* and *R. solani* (Krishnamurthy *ei al.*, 2001). Codon-optimised cecropin A (an antimicrobial peptide) from giant silk moth was expressed in rice which exhibited resistance to rice blast at various levels (Coca *et al.*, 2006). Experimental data indicated that resistance to blast in transgenic rice expressing cecropin A may be a consequence of a combination of antifungal activity of cecropin A and cecropin A-mediated over-expression of rice genes (Campo *et al.*, 2008). Antimicrobial peptide thanatin has strong and wide range of antimicrobial spectrum including certain types of fungi and gram negative and gram positive bacteria. Introduction of thanatin gene was useful in generating transgenic rice plants effective against *M. oryzae* (Imamura *et al.*, 2010). Transgenic rice plants expressing knottin type antimicrobial peptide *Mj*-AMP2 showed enhanced blast resistance (Prasad *et al.*, 2008). Resistance to *M. oryzae* resulted where antifungal AFP protein was expressed under a promoter that is induced by fungal infection, treatment with fungal elicitor and mechanical wounding (Monero *et al.*, 2005). Two plant defensin genes *Dm-AMP1* and *Rs-AFP2* were expressed singly each and as polyprotein in transgenic rice and there was significant improvement in disease resistance against *M. oryzae* and *R. solani* (Jha *et al.*, 2008; Jha and Chattoo, 2009). Transgenic rice over-expressing *wasabi* gene exhibited resistance at various levels. The transgenic rice plants were expected to possess a durable and wide spectrum of disease resistance against various rice blast races (Kanzaki *et al.*, 2002). Grapevine *Stilbene synthase* required for synthesis of phytoalexin resveratol was transferred to rice and preliminary results indicated enhanced resistance of transgenic rice to *M. oryzae* (Lorenza *et al.*, 1997). Expresison of a gene encoding trichosanthin (a type of ribosome-inactivating protein) in transgenic rice plants enhanced fungal blast disease. The lesions on the leaves were much less severe and seedling survival rate and whole plant height were higher than those of control plants (Yuan *et al.*, 2002).

Exploitation of genes from microbes that can elicit defense response :

Expression of hairpin-encoding gene (*hrf1*), derived from *X. oryzae* p.v. *oryzae* in rice conferred non-specific resistance to *M. oryzae*. The expression of defense-related genes was activated in resistant transgenic plants (Shao *et al.*, 2008). Expression of an elicitor-encoding gene (*pemG1*) from M. oryzae enhanced resistance against blast in transgenic rice (Qiu *et al.*, 2009). Transgenic rice plants expressing proteinaceous elicitor flagellin showed enhanced resistance to *M. oryzae*. Expression of defense-related gene for phenylalanine ammonia lyase, H_2O_2 production and cell death were observed in transgenic rice plants (Takakura *et al.*, 2008). *OsSBP*, a rice homologue of mammalian selenium-binding protein, was isolated as one of the genes induced by treating the plant with cerebroside elicitor from *M. oryzae*. Plants over-expressing *OsSBP* showed enhanced resistance to *M. oryzae* and *X. oryzae p.v. oryzae*. In the transgenics expression of defense-related genes and accumulation of phytoalexins increased following infection (Savada *et al.*, 2004).

Exploitation of effective non-defense-related genes :

The lesion sizes of blast in transgenic rice plants expressing gene for bialaphos resistance (*bar*) were decreased following treatment with bialaphos. Pre-treatment of plants with herbicide also suppressed disease symptoms to 20% of control plants (Tada *et al.*, 1996). Herbicide glufosinate ammonium was shown to impede development of appressorium of rice blast pathogen. Chlorosis and diminished chlorophyll content were completely restored in *bar*-transgenic rice. In addition, glufosinate ammonium triggered transcription of PR genes and accumulation of H_2O_2 in transgenic rice was observed. Thus, direct inhibition of pathogen infection and activation of defense systems were responsible for disease resistance in *bar*-transgenic rice (Ahn, 2008). Functional association of flavonoids with plant stress response has been widely reported in the literature. Regulatory (C_1 and *R*) and structural (*C2*) genes for anthocyanin pigmentation were engineered into rice plants and preliminary screening of transgenic plants revealed enhanced resistance against *M. oryzae* (Gandikota *et al.*, 2001). Transgenic rice cells over-expressing *Arabidopsis* Bax inhibitor (*Bl.1*) showed sustainable cell survival when challenged with *M. oryzae* elicitor (Matsmura *et al.*, 2003). Rice blast fungus secretes IAA which may induce rice to synthesize its own IAA. This plant hormone induces production of expansin (cell wall loosening proteins) which makes rice vulnerable to pathogen infection. Expression of *GH3-2* encoding IAA-amido synthetase inactivates IAA by catalyzing the formation of IAA-amino acid conjugate. Activation of this gene in rice resulted in suppression of expansin genes and thus, mediating broad spectrum resistance to *X. oryzae* p. v. *oryzae*, *X. oryzae* p. v. *oryzicola*, and *M. oryzae* (Fu *et al.*, 2011).

Engineering lipid metabolism of plants :

SA, JA, and ethylene are much known signals in plant defense. Fatty acid (FA) and FA-derived signals have started to emerge as important regulators of plant defense pathways (Kachroo *et al.*, 2005). Linoleic acid (18:2) and Linolenic acid (18:3) are sources for various oxidized metabolites called oxylipins some of which inhibit growth of fungal pathogens. Linolenic acid deficient transgenic rice plants were generated with co-suppression of *OsFAD7* and *OsFAD8* encoding two ω-3 fatty acid desaturases. These transgenic plants showed enhanced resistance to *M. oryzae* (Yara *et al.*, 2007). It was demonstrated that 18:2-derived hydroperoxides and hydroxides inhibited growth of *M. oryzae* more strongly than 18:3-derived components (Yara *et al.*, 2008).

Prospects of genetically modified crop plants and thrust areas :

Already, the countries like United States of America (USA), Argentina, Brazil, India, Canada, China, Paraguay and South Africa are growing genetically engineered crop plants such as alfalfa, canola, cotton, soybean, corn, papaya, sugarbeet, petunia, sweet pepper, tomato etc. Among these countries USA has devoted the largest land area for cultivation of GM crops. International Service for the Acquisition of Agri-Biotech Applications (www.isaaa.org) expects that number of countries growing GM crops will go up to 40 by 2015. Several new disease and pest resistant GM crops are also awaiting approval of the competent authority to be grown up in the field. However, to ensure future food security and appreciate the application potential of genetic engineering the following areas should be given due importance.

1. Strengthening the research expertise in genetic engineering.
2. Increased public-private partnership in transgenic research and development.
3. Gene mining and integration of transgenic approach to conventional plant breeding.
4. Development of "marker-free" transgenic plants.
5. Toxicity and allergenicity tests should be done on a case-by-case basis.
6. Environmental concerns should be evaluated on a case-by-case basis.
7. Formulation of clear biosafety guidelines and development of a network between agricultural universities, various institutes, other relevant laboratories and biosafety committees.
8. Comprehensive survey of given crop species, existing wild and weedy relatives for risk assessment.
9. Awareness programmes in schools, colleges and universities and other institutes / organisations for the laymen to make safe and responsible use of transgenic products.

Conclusion :

Today scientists and plant breeders are hard-pressed to feed the exploding human population under the threat from various biotic and abiotic stress conditions and limited available land area that is arable. However, molecular plant breeding is bound to reap the direct and indirect benefits from genomics research. The challenge is to gain lot more significant insights about molecular basis of host defence systems. All this information coupled with newer functional genomics approaches and bioinformatics resources presents excellent opportunity for molecular breeding of crop plants.

References :

1. A. Kachroo, Z. He, R. Patkar, Q. Zhu, J Zhong, D. Li, P. Ronald, C Lamb, B B. Chattoo, *Transgenic Research.* 12, 577-586 (2003).
2. A. Yara et al, *BBRC.* 376, 460-465 (2008).
3. A. Yara et al, *Plant Cell Physiol.* 48(9), 1263-1274 (2007).
4. A B. Monero et al, *Molecular Plant Microbe Interaction.* 9, 960-072 (2005).
5. B.D Prasad, G. Creissen, C. Lamb, B.B. Chattoo, *Molecular Plant Microbe Interaction.* 22, 1635-1644 (2009).

6. B.D. Prasad, S. Jha, B.B. Chattoo, *Plant Science*. 175, 364-371 (2008).
7. C. J. S. Smith, C. F. Watson, J. Ray et al., *Nature*, 334, 724-726 (1988).
8. C. Mei, M. Qi, G. Sheng, Y. Yang, *Molecular Plant Microbe Interaction*. 19, 1127-1137 (2006).
9. C.C.Giri and G.V. Laxmi, *Biotechnology Advances*. 18(8): 653-683 (2000).
10. D. Qiu, J. Mao, X. Yang, H. Zeng, *Plant Cell Rep*. 28, 925-933 (2009).
11. E .John, Sheehy and P.L. Mitchell, *Chapter 8*, page 81-90 (2011).
12. F. J. Perlack, R. W. Deanton, T. A Armstrong et al., *Nature Biotechnology*, 8, 939-943 (1990).
13. H. Kanzaki, S. Niraswa, H. Saitoh, M. Ito, M. Nishihara, R. Terauchi, I. Nakamura, *Theoretical Applied Genetics* 105, 809-814 (2002).
14. H. Matsmura et al, *The Plant Journal*. 33, 425-434 (2003).
15. H. Yuan, X. Ming, L. Wang, P. Hu, C. An, Z. Chen, *Plant Cell Reports*, 20, 992-998 (2002).
16. Innercone et al., *Plant Molecular Biology*, 34, 485-496 (1997).
17. J. Fu, H. Liu, Y. Li, H. Yu, X. Li, J. Xiao, S. Wang, *Plant Physiology*. 155, 589-602 (2011).
18. J. Quilis, G. Penas, J. Maesseguer, C. Brugidou, B.S. Segundo, *Molecular Plant Microbe Interaction*. 21, 1215-1231 (2008).
19. J. Zhang, Y. Peng, Z. Guo, *Cell Research*. 18, 508-521 (2008).
20. J.G. Dubouzet et al, *Plant Biotechnology Journal*. 9, 466-485 (2011).
21. J.L. Dangle and J.D.G.Jones, *Nature*. 411, 826-833 (2001).
22. K. Krishnamurthy, C. Balconi, J.E. Sherwood, M.J. Giroux, *Molecular Plant Microbe Interaction*. 14, 1255-1260 (2001).
23. K. N. Reddy, Weed Biology and Management, 1, 193-202 (2001)
24. K. Sawada et al, *Biosci. Biotechnol. Biochem*. 68 (4), 873-880 (2004).
25. L. Mei, S. Zong-xiu, Z. Jie, X. Tong, H.E. Gary, L. Maatteo, *Journal of Zhejiang University SCI*.5(2), 133-136 (2004).
26. M. Coca, G. Penas, J. Gomez, S. Campo, C. Bortolotti, J. Messguer, B.S. Segundo, *Planta*. 223, 392-406 (2006).
27. M. Gandikota et al, *Molecular Breeding*. 7, 73-83 (2001).
28. M. Kawata., T. Nakajima, T.Yamamoto, K.Mori, T.Oikawa, F.Fukumoto and S. Kuroda, *JARQ*. 37(2), 71-76 (2003).
29. M. Mannerlof, S. Tuvesson, P. Steen and P. Tenning, Euphytica, 94, 83-91 (1997).
30. M. Shao, J. Wang, R.A. Dean, Y. Lin, X. Gao, S. Hu, *Plant Biotechnology journal*. 6, 73-81 (2008).
31. M. Shimono et al. *The Plant Cell*. 1-13 (2007).
32. M.A. Ayliffe, and E.S. Lagudah, *Annals of Botany*. 94, 765-773 (2004).
33. M.H. Stuiver, and J.H.H.V. Custer, *Nature*. 411, 865-868 (2001).
34. P. A. Kumar, A. Mandaokar, K. Sreenivasu et al , *Moleular Breeding*, 4, 33-37 (1998).
35. P. Ahn, *Plant Physiology*. 146, 213-227 (2008).
36. P. Kachroo et al, *Plant Physislogy*. 139, 1717-1735 (2005).
37. P. Stark-Lorenza, B. Nelke, G. Hanbler, H.P. Muhlbach, J.E. Thomzik, *Plant Cell Reports*. 16, 668-673 (1997).

38. R. C. Lundquist and M. N. Walters, US Patent No. 5,554,798 (1996).
39. R.N. Patkar and B.B. Chattoo, *Molecular Breeding*. 17, 159-178 (2006).
40. S. Campo , S. Manrique, J.G. Martinez, B.S. Segundo, *Plant Biotechnology Journal*. 6, 585-608 (2008).
41. S. Jha, and B.B. Chattoo, *Transgenic Rice*. DOI 10.1007/s 11248-009-9315-7 (2009).
42. S. Jha, H.G. Tank, B.D. Prasad, and B.B. Chattoo, *Transgenic Research*. 18, 59-69 (2008).
43. S. Roy-Barman, C. Sautter, and B. B. Chattoo, *Transgenic Research*, 15, 435-446 (2006).
44. T. Imamura, M. Yasuda, H. Kusano, H. Nakashita, Y. Ohno, T. Kamakura, S. Taguchi, H. Shimada, *Transgenic Research*. 19, 415-424 (2010).
45. T. Tada, H. Kanzaki, E. Norita, H. Uchimiya, I. Nakamura, *Molecular Plant Microbe Interaction*. 9, 758-759 (1996).
46. Takakura et al, *Molecular Plant Pathology*. 9(4), 525-529 (2008).
47. U. Schaffrath, F. Mauch, E. Freydl, P. Schweizer, R. Dudler, *Plant Molecular Biology*. 43, 59-66 (2000).
48. X. Chen and Z. Guo, *Int. J. Mol. Sci*. 9, 2601-2613 (2008).
49. X. Chen et al, *The Plant Journal*. 46, 794-804 (2006).
50. X. Ye, S. Al-Babilli, A. Klotti et al., *Science*, 287, 303-305 (2000).
51. Y. Itoh et al, *Biosci. Biotechnol. Biochem*. 67(4), 847-855 (2003).
52. Y. Nishizawa, Z. Nishio, K. Nakazono, M. Soma, E. Nkajima, M. Ugaki, T. Hibi, *Theoretical and Appiedl Geneicst*. 99, 383-390 (1999).
53. Z. K. Punja, *Can. J. Plant Pathol*. 28, S298-S308 (2006).
54. Z. K. Punja, *Can. J. Plant Pathol*. 23, 216-235 (2001).
55. Z.N. Hao, J. Wang, L.P. Wang, and R.X. Tao, *African journal of Biotechnology*. 8, 4845-. 4848 (2009).

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www.isaaa.org

IMPORTANT DISEASES OF VEGETABLE CROPS AND THEIR MANAGEMENT WITH SOME BIORATIONAL AGROCHEMICALS

S.Saha, M.Loganathan, A.B.Rai and R. Garg

Introduction :

Vegetables form an integral part of the national cropping system and hence plays a pivotal role in the country's economy by maintaining the livelihood as well as nutritional security. Diseases are one of the major bottlenecks of the sustainable production of vegetables and hence needs to be controlled to bolster the production. Various methods have been adopted to control the menace of diseases and use of appropriate fungicides is the major weapon to combat the menace. Conventional fungicides when amalgamated with the new biorational molecules become an indispensable tool for the farmers to manage the disease. The present article deals with the major diseases of vegetable crops and their chemical control thereof.

Tomato :

Early Blight (c.o. *Alternaria solani*) :

Symptoms appear in all aerial parts of the plants. Leaf spot symptoms are scattered, brown with concentric rings and often with chlorotic halo. The spots coalesce later leading to necrotic patches. Sunken stem lesions are usually restricted to one side of the stem while on the fruits the spot radiate out from the attachment between calyx and fruit.

Pathogen is soil, seed as well as air borne and requires a temperature of 8°-30°C for conidia germination

Management :

Two sprays of chlorothalonil @ 2gm/litre of water at 8 days interval is effective against the disease.Two to three sprays of mancozeb or zineb @ 2gm/litre of water at 7-10 days interval is also recommended.

Late blight (c.o *Phytophthora infestans*). :

Blight appears on foliage as light pale green water soaked area, which enlarges rapidly and covers entire leaves. Green and ripe fruits affected by blight appeared brownish and internal tissues become spongy with bad odour.

Excessive humidity (above 90%RH) coupled with cool moist conditions favour the disease development. The sporangia are viable in soil having moisture level of 15-20%.

Management :

Preventive sprays of mancozeb @ 2.5 gm/lit. provide good control but in cloudy, cold and drizzling weather the spray interval should be 5 to 7 days.Two sprays of fenamidone + mancozeb @ 2 gm/ litre of water or dimethomorph+metiram @

1g+2g/litre of water at 10 days interval is very effective after the symptoms are seen in the plants.

Bacterial spot (c.o *Xanthomonas campestris* pv. *vesicatoria*) :

Small, dark spots appear on the leaflets and stems of seedlings of transplanted crop, which coalesce and form severe burning of the leaves. Slightly raised small water soaked spots, corky in appearance are seen on the surface of green fruits

The pathogen requires high relative humidity and optimum temperature (24°C) for its growth and multiplication.

Management :

One spray of streptocycline @ 150-200 ppm followed by one spray of copper oxychloride @ 2.5 g/litre of water at 12 days interval gives good control.One repeat spray of copper hydroxide @ 3 g/litre of water after fifteen days of copper oxychloride application protects from secondary infection.

Bacterial canker (c.o *Clavibacter michiganensis pv.michiganensis*) :

Symptom is characterised by absence of chlorotic halo around spot, crusty and comparatively larger spots than in bacterial spots. The spots are necrotic, circular and the tissue around the spots retains its green colour longer than normal. Irregular and elongated lesions on stem are also observed.

Bacteria live for a long term in or on seeds and diseased plant debris in soil. The disease develops at temperature as low as 16°C and as high as 36°C but the optimum is 28°C.

Management :

Seed dipping in streptocycline solution @100 ppm for 10 minutes.One spray of streptocycline @150-200 ppm followed by one spray of copper oxychloride @ 3 g/litre of water after fifteen days

Leaf curl complex :

It is a viral disease where leaves show downward rolling, curling, twisting and chlorosis. Plants exhibit stunting with short of internodes and a bushy appearance. Flowering and fruiting are absent at later stage of viral infection. The virus is transmitted by whitefly.

Management :

Root dipping in Imidachloprid solution @ 4-5 ml/litre of water for 30 minutes prior to transplanting of the seedlings. Seed treatment with 10% tri sodium phosphate solution for 25 minutes. Periodical sprays of systemic insecticides like Imidachloprid or Thiamethoxam up to flower setting.

***Chilli* :**

Die Back/ Fruit Rot /Anthracnose - (c.o *Colletotrichum capsici*) :

As the fungus causes necrosis of tender twigs from the tip backwards the disease is called die-back. Infection usually begins when the crop is in flowering stage.

Infected flowers dry up and drop. On ripe fruits circular spots and sunken lesion with slightly raised rim are seen. The sunken spot is covered with a pinkish mass of fungal spore. As the disease advances the spots spread forming concentric marking and dark black fructifications represent the fungal acervuli. Germination of conidia occurs at 30°C and 100% RH

Management :

Seeds should be obtained from diseased free fruits and treated with thiram @ 1.5-2 g/kg of seeds to remove the seed borne inoculum.Foliar spray of carbendezim @ 1 g/lit followed by copper oxycloride @ 3 g/lit at flowering stage is recommended to manage the disease.Two sprays of flusilazole or kresoxim methyl @ 1 ml/litre of water at 12-15 days interval is also used.

Wilt (c.o *Fusarium oxysporum f.sp.capsici*) :

It is characterised by wilting of the plants with upward and inward rolling of the leaves. Severely infected plants wilt and die. Discolouration of the vascular system of the plant particularly the lower parts of stem and roots is a typical symptom of Fusarium wilt disease.

The optimum temperature for disease development is around 28°C. Disease is severe at low pH (below 6.4) and above pH 7.0 along with short day length and low light intensity

Management :

Drenching with 1% Bordeaux mixture or copper hydroxide @ 2.5 g/litre of water may give initial protection.Seed treatment with 1g Carbendazim per kg seed is effective .Soil drenching with tebuconazole @ 1.5 ml/litre of water or propiconazole @ 1 ml/litre at regular intervals of 15 days is reported to control the disease.

Leaf curl :

A major viral disease causing reduction in size of leaves and shortening of veins. Small dark green conspicuous thickening of veins are visible on lower side of the leaves. Leaf puckering. and mottling, stunting, and bushy appearance of the plant are also observed.

Management :

Root dipping in Imidachloprid solution @ 4-5 ml/litre of water for 30 minutes prior to transplanting of the seedlings. Periodical sprays of systemic insecticides like Imidachloprid or Thiamethoxam up to flower setting.

***Okra* :**

Yellow Vein Mosaic :

It is caused by a Gemini Virus which is transmitted by whitefly.

Symptoms appear as prominent yellow vein and vein lets having green interveinal area. The yellow network of veins is very conspicuous and the veins and veinlets are thickened. Fruits become green to yellow and become hard in early stage of growth.

Management :

Seed treatment with Imidachloropid @ 5 ml per kg of seed.Periodical spray of safe systemic insecticide and neem seed kernel extract up to flowering stage

Leaf blight (c.o *Cercospora abelmoschi / hibisina*) **:**

No definite leaf spot is caused by the fungus but grow as sooty to dark olivaceous ectoparasite covering entire leaf lamina. Symptoms are first visible in the lower leaf lamina and gradually covers both the sides, thereby reducing the photosynthetic area. Sometimes light brown lesions are observed after washing out of spores from surface of leaves.

The pathogen is seed borne and secondary spread is by air.

Management :

Two to three foliar sprays of difenoconazole @ 0.25 ml or hexaconazole @ 0.5 ml per litre of water at 6-7 days interval can manage the disease efficiently.***Cabbage/ Cauliflower* :**

Black rot (c.o. *Xanthomonas axonopodis pv axonopodis*) **:**

Plant is susceptible throughout its growing season . The leaf tissues turn yellow and the chlorosis progresses towards the center of the leaves forming V shaped lesion towards the midrib. Blackening of the veins is associated. Secondary infection with *Erwinia* sp causes rotting of the head.

The optimum temperature for growth of bacterium is about 26.5°C-30°C

Management :

Seed treatment with streptocycline (0.1 gm/lit) followed by periodic spray of copper hydroxide @ 3 g/litre of water gives good control of the disease.If mixed infection with *Erwinia* sp is observed kasugamycin @ 2 ml/litre of water and copper oxychloride @ 3 g/litre of water may be sprayed alternately to control the disease.

Club Root (c.o *Plasmodiophora brassicae*) **:**

The aerial parts may show stunting, reduction in size of head or chlorosis and the roots are malformed into thick, fleshy club- like structure. Abnormal wilting especially on warm sunny days is also evident.

The fungus persists in soil as resting spore in diseased host tissue

Management :

Maintenance of soil pH over 7.2 is the best means of control. For faster activity a minimum of 2.5 t/ha limestone can be added (regardless of soil pH) at least six weeks prior to field transplanting.

Leaf spot (c.o. *Alternaria brassicae/ brassicicola*) **:**

The lower leaves are infected first with brown circular spots which have characteristic concentric rings giving it a "target board appearance". Infected leaves soon turn yellow and drop.

Management :

Use of healthy seeds treated with Captan or Thiram @ 3 g/kg of seed.Spray of Mancozeb @ 2.5 g/litre of water or Chlorothalonil @ 2 g/litre of water or azoxystrobin @ 1 ml/litre of water along with sticker @ 1 ml/litre of water is effective in controlling the disease.

Cucurbits (Cucumber, Pumpkin, Bottle gourd, etc) :

Downy mildew (c.o *Pseudoperonospora cubensis*) **:**

Fine hair like downy growth of fungus is observed on lower surface of the leaves.It affects plants of all ages. Although the disease only infects foliage, a reduction in photosynthetic activity early in plant development results in stunted plants and yield reduction. Premature defoliation may also result in fruit sunscald due to overexposure to direct sunlight. Symptoms of downy mildew infection exhibit themselves differently on the various cucurbit crops.

Management :

Application of metalaxyl+mancozeb @ 2-2.5 g/litre of water at 7-10 days of interval.In case of severe infection alternate sprays of fenamidone mancozeb @ 1.5 g/ litre of water or cymoxanil. + mancozeb @ 2 g/ liter of water at 10-12 days interval will be beneficial.It is important to get good coverage of the lower leaf surfaces, as infections commonly occur on the undersides of leaves.

Powdery mildew (c.o. *Erysiphe cichoracearum*) **:**

Powdery mildew is diagnosed by white, powdery mold on plant tissues. The disease first appears on lower stems and petioles. As the disease continues to develop, the white, moldy spots occur on the underside of leaves. Distortion of leaves are also observed in severe case.

Management :

Application of azoxystrobin @ 1ml/Litre of water at 7-10days interval will give good control of the disease.Flusilazole @ 1 ml/liter of water and myclobutanil @ 1 g/10 litre of water may also be applied for managing the disease.

Angular Leaf spot (c.o *Pseudomonas syringae pv lachrvmans*) **:**

This is common seed-borne disease of cucumbers which in wet seasons can cause considerable yield losses. Discrete angular yellow spots are seen on the lamina which gives the leaves a scorched appearance. Shot hole symptoms and cracking of infected tissues are also observed.

Management :

Application of copper hydroxide @ 2 g/litre of water gives good control of the disease

Brinjal :

Blight (c.o *Phomopsis vexans*) **:**

The fungus attacks all parts of the plants above ground. Dark brown lesions appear on the stem and round to oval spots are formed on the leaves. Diseases fruits show small watery lesions which later on become black and mummified.

Management :

The disease can effectively be controlled by weekly spraying of nursery and field with zineb or mancozeb @ 2.5 gm per litre of water. Spraying of carbendazim + mancozeb @ 1.5 g/litre of water also gives good control of the disease.

Bacterial wilt (c.o. *Ralstonia solanacearum)* :

Characteristic symptoms of the disease are wilting , stunting, yellowing of the foliage and finally the entire plant collapses. The vascular system turns brown and if a segment of the lower stem is cut and squeezed it yields bacterial ooze. The pathogen is soil-borne and persists for long period in soil

Management :

Disease is partially controlled by soil solarisation and mulching.Crop rotation with paddy rice and broccoli vegetables is reported to reduce soil-borne inoculum.

Conclusion

Vegetables, an integral part of the national cropping system, one of the backbone in the country's economy by maintaining the livelihood as well as nutritional security. Diseases are one of the major factors that interfere the sustainable production of vegetables. Conventional fungicides when amalgamated with the new biorational molecules become an indispensable tool for the farmers to manage the disease and to improve productivity.

References

1. Diseases of Horticultural crops: Vegetables. Ornamentals and mushrooms. Ed: Verma, L. R and Sharma, R. C (2001) Pub : Indus Publishing Company, New Delhi pp731
2. Integrated Insect, Mite and Disease Management on Vegetable Crops (2010) Ohio Vegetable Production Guide pp. 32-45
3. http://veg-fruit.cropsci.uiuc.edu, http://www.ag.uiuc. edu/~vista/pubs.html, and http://ipm.uiuc.edu
4. http://www.APSnet.org
5. www.cals.uidaho.edu/edcomm/pdf/CIS/CIS0993.pdf

VEGETABLE MITE MANAGEMENT WITH RECENT ACARICIDES

Dr. P. K. Sarkar

Vegetable cultivation in India has attained greater importance during the last decade. Vegetables form the most important component of balanced diet. India is the second largest producer of vegetables in the world next only to China with an estimated production of about 80.26 million tonnes from an area of 5.57 million ha with an average yield of 14.4 tonnes per ha. It accounts for about 9.3 per cent of the world's vegetable production (Anon.,2005).Solanaceous vegetables *viz.*, brinjal, chilli, potato and tomato are grown throughout the year in all parts of the country in an area of 32.98 lakh ha with the production of 441.7 lakh tonnes. Amongst which, brinjal, *Solanum melongena* L. is one of the most common and principal vegetable crop. It is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and Philippines. The area under brinjal cultivation in India is 5.10 lakh ha and its production is 88 lakh tonnes with an average yield of 17,250 kg per ha during 2000-01 (Singhal, 2003). In Karnataka, it is cultivated over an area of 3.77 lakh ha with an average productivity of 17.63 tonnes per ha (Anon., 2001). These solanaceous vegetables are mainly used for culinary purposes. They are rich source of vitamins, minerals, proteins, carbohydrates and trace elements. Some of the solanaceous vegetables contain alkaloid *viz.*, solanin (brinjal) and capsicin (chilli), which have medicinal properties.

Like other crops, these solanaceous vegetables are also ravaged by several insect and non-insect pests throughout the growing period. Among the non- insect pests of agricultural crops, mites are probably the most notorious ones and gaining tremendous importance in the recent years due to their devastating nature. Huffaker *et al.* (1969) proposed two main hypotheses concerned to mite outbreaks in recent decades. One is the general upsurge of mite due to stimulative effects of pesticides and fertilizers promoting increased plant growth and better nutrition to mites. This has resulted in increased reproductive potentials of mites. Another is detrimental effect of pesticides on mite enemies.

The phytophagous mites belong to four important families *viz.*, Tetranychidae (spider mites), Tenuipalpidae (false spider mites), Eriophyidae (gall mites) and Tarsonemidae(broad/yellow mites). In vegetables spider mite damage alone causes 10 to 15 per cent loss in yield (Anon., 1991). Out of 37 mite species known to feed upon vegetable crops, six species *viz.*, *Tetranychus cinnabarinus* (Boisduval) (=*urticae* Koch), *T. neocaledonicus* Andre, *T. ludeni* Zacher, *T. macfarlanei* Baker and Pritchard, *Aceria lycopersici* (Wolff.) and *Polyphagotarsonemus latus* (Banks) are serious pests mostly of vegetables like brinjal, okra, cucurbit, chilli, potato etc in major parts of the country (Gupta, 1991). Many reports indicate that mites suck the sap from the leaves producing small white specks, which gradually coalesce as feeding continues. Leaves loose their green colour, gradually wilt, dry and drop off. The decreased vitality and leaf drop adversely affect plant growth, flowering and fruiting. In severe infestation, tetranychid mites web profusely and may form a thick sheath of webbing that covers the entire plant (Grandjean, 1948 and Jeppson *et al.*, 1975). These webs get filled with soil particles in windy weather and inhibit the photosynthetic activity of the plant. Thus the mite has been proved as an indirect pest causing loss in quality and quantity of the yield . Besides, phytophagous mites also inject toxic substances into hosts causing disruption in tissues and increase in localized growth (Channabasavanna, 1966).

Mites are smallest organisms under Sub-class ACARI. World wide distribution and affect human life directly /indirectly. They are rich in bio-diversity: > than 40,000 spp, under > than 1800 genera has been described in details. Occupy every habitat of life. Plant feeding mites (phytophagous) : attacks cultivated crops, ornamentals & wild plant. Some spp. serving as vector of plant diseases. Problem of phytophagous mite became intensed during fifties (green revolution era). Huge amount of insecticides controlléd the pests as well as affected the natural enemies. Absence of insects in competition for food and absence of natural enemies viz., parasite & predators, the phytophagous mite population increased enormously. Mite species which were never seen earlier have become important pests (coconut eriophyid mite, Paddy leaf sheath mite etc.).

Egg, larva, protonymph, deutonymph and adult. Four pairs of legs; three pairs on larva,1 body segment,Chelicerae, fangs like spiders,They suck cells, cause chlorosis; yellowing of foliage,transmit disease. Diagnostics: chlorosis, webbing, rusetting, galls. Female: round abdomen,Male: pointed abdomen,Larva: 3 pairs of legs.

Crop losses due to different mite spp. :Mango: 50-80 % (*Aceria mangiferae*),Rice: 15-20 % (*Steneotarsonemus spinki*),Tea : 20-60% (*Oligonychus coffeae*).Sugarcane:10-25 % (*Schizotetranychus andropogoni), Coconut: 25-75 % (Aceria guerroronis),*Vegetables: 10-50% (*Tetranychus urticae*). Total failure of crops due to mite infestation has been reported in Bhindi & Chilli.

Spider mites are small, often difficult to see without a hand lens. Color varies with species and even with the time of year: colorless red, brown, yellow and green spider mites are common. Spider mites puncture plant tissue with piercing mouthparts to feed on plant juices. Chlorophyll is removed along with plant fluids. As a result, plants infested with spider mites have a white or yellow speckled appearance. The plants look dull and unthrifty. Mites feed primarily on the undersides of leaves, out of sight and away from direct sunlight. Heavy infestations discolor leaves. When mites feed on fruit, it causes bronzing or russeting. This discoloration makes the fruit cosmetically unappealing but seldom damages the edible interior of the fruit. Heavily infested plants drop their leaves prematurely. Several species of spider mites occur in vegetables, but, The two-spotted spider mite is the most widespread. As air temperatures warm in the spring, mites become active and begin to feed and mate. Adult females may lay dozens of eggs or more over a two week period. Eggs hatch into six-legged larvae, and then pass through two eight-legged nymph stages before becoming adults. This takes a few days to several weeks depending on environmental conditions, the availability of food, and pressure from natural enemies. Environmental conditions have an important influence on the development of spider mite populations. Populations grow rapidly when weather is hot and humidity is low, and when plants are water-stressed from drought or improper irrigation. Problems with mite injury are most common on hot, dry, dusty sites. In addition, dusty conditions inhibit the effectiveness of natural enemies of spider mites, which are not as well adapted to these harsh circumstances.

Number of active life stages of different plant feeding groups (phytophagous) of mites:-

a. Tarsonemidae: 2 stages (larva & adult)
b. Tetranychidae: 4 stages (larva, protonymph,deutonymph,adult)
c. Tydidae: 5 stages (larva, proto, deuto, tritonymph and adult.)
d. Eriophyidae: 2 stages (Ist stage nymph and second stage nymph).

Some common plant feeding mites of vegetables and their symptomps of damage&,ecology etc.:-

***Tetranychus urticae* Koch (Two spotted spider mite)**

Diagnosis: Greenish or yellowish mite , large spots on either side of the body.
Host: Brinjal,Marigold, Rose,Cowpea, French Bean,Pea etc.
Damage: Speckles develop due to feeding, some times crop can be covered with web. Results in loss of vitality and affects yield. Infested leaves become crinckled, crumpled and fall off.
Period of Incidence: February onwards till May/June. Peak period March-April (Pre- monsoon months) , Low population – June – December.

***Tetranychus neocaledonicus* Andre**:

Diagnosis : Reddish coloured mite Female oval shaped & male pear shaped.
Host: Bhindi, Potato, Croton, *Luffa acutangula*, Brinjal.
Damage: Same as *Teranychus urticae*
Period of incidence: Peak period May.Low population: June – December, Population increases with increase in RH & maximum temperature.

***Panonychus citri* (McGregor):**

Diagnosis: Reddish mite with reddish dorsal long setae on strong tubercles.
Host:Citrus, Papaya, Jackfruit, Apple.
Damage: Damages chlorophyll. Resulting in the appearance of speckles. Retardation of growth & defoliation. Browning and drying of terminal tip is common.

***Polyphagotarsonemus latus* (Banks):**

Diagnosis: Body oval, Tiny, Broader frontal parts.Glossy or whitish
Host :Jute, Chilli, Chrysanthemum, Dahlia, Tea, Potato and many others.

Ecology : Remains in the field throughout the year on different crops. Population dwindles during Rainy season.

Damage: Attacks young foliage (under surface). Silvery appearance- later turns Bronzy. Edge of the leaves Curl Down (Inverted Boat shape: Chilli). Underside of lamina become reddish brown(Cowpea). Internodes shortened (Jute). Elongation of petiole (Chilli), Bullet holes on older leaves (Chilli) in some varieties.

***Brevipalpus californicus Donnadieu* :**

Diagnosis: Body pear shaped, flat. Constriction between 2nd & 3rd Coxal base.

Host: Maize, Lady's Finger, Bitter Gourd, Snake Gourd, Guava

Damage: Remain under side near mid rib.Very sluggish movement. Feeding results in appearance of Yellow spots- turns brown & coalesce to form brown patches. Petiolar arrangement become very weak. Vigour of plants very much retarded.

Ecology: Remain through out the year. Low temp & low humidity are favorable. Maximum population during Dec-March.

Use of control agents :

Only when needed (economic threshold when available, otherwise timed early in the development of populations), correct dosage and proper spray intervals, proper timing (treat as early as possible against red spider mite to effectively limit the build-up of the 1st spring/summer generation; for bud mite application to be timed with the migration phase).

Some guidelines :

Good field sanitation eliminating alternate host plants. Efficient cultural practice & conservation of bio-control agents. Timely application of acaricides against the most susceptible life stages based on local pest thresholds. Sequential application of acaricides (not single acaricide class).Using acarcides at recommended rates and spray intervals. When more than one clear generation of mites recorded, acarcides of different classes for different generation of mites to be used. In the event of control failure, assessment to be based on following parametres: Whether application of unsuitable acarcides taken place or insufficient coverage of acarcides or development of resistance in mites to pesticides. Tank mixture components of different classes of pesticides to be used at effective equivalent control rates.

When making the decision on which acarcide to use, several factors to be balanced :

Chemical control of spider mites involves the use of pesticides specifically developed for the control of mites, called miticides or acaracides. There are typically several generations of spider mites each season. As a result, they are capable of developing resistance to most miticides very rapidly. To minimize the development of resistance to a pesticide, minimize pesticide applications and integrate other control measures: use biological and cultural controls first, and if necessary to prevent severe infestations, choose a miticide rather than a "broad spectrum" insecticide. The chemical give effective mite control under the prevailing crop and weather conditions. Is there any resistance to it in the prevailing area. Will it give a good knock-down to existing mite populations. Will it give prolonged protection.Is the total cost of mite control economic. Chemicals showing toxicity to motile stages of the mite population usually are more effective in commercial control, because the proportion of these stages in the mite population is generally high and the feeding damage is inhibited immediately. Larval, nymphal and adult stages move about sufficiently to come into contact with toxic residues that are on the leaf surfaces. It is advocated that prophylatic sprays with azadirachtin enriched neem formulations altemated with sulphur at the very initial stage would help to conserve natural enemies of plant feeding mites.

Most of the microbial formulations available in India are also ineffective except commercial formulation of *Streptomyces*. Neem oil & Neem Kernel extract are ineffective. However only Aza based formulation 10,000 ppm & 50,000 ppm are effective.

Different types of available formulation :

- **EC** (Emulsifiable concentrate), **SL** (soluble liquid), **SC** (suspension concentrate), **FC** (flowable concentrate), **ULV** (ultra low volume), **ULC** (ultra liquid concentrate).
- **EW** (emulsion oil in water), **OL** (oil missible concentrate), **CS**(capsule suspension).

Formulation of pesticide (dry) :

- Dusts **(D)**, Granules **(G)**, Wettable Powder **(WP or W)**, Soluble Powder **(SP)**

The first serious and widespread spider mite outbreaks following applications of neuroactive insecticides, were observed at the end of 1940s and beginning of 1950s, initiated the research and development of specific acaricides. These compounds, exclusively or primarily effective against mites, were gradually taking over the organochlorines, organophosphates and carbamates. **Bridged diphenyls** (bromopropylate, chloropropylate, chlorobenzilate,chlorfenethol, dicofol, tetradifon), the first specific acaricides, established themselves on the market in the 1950s. During the 1960s and early 1970s, the second generation of structurally rather different specific acaricides emerged, the most important of which were **propargite, organotins**(cyhexatin, fenbutatin-oxide) and **formamidines** (amitraz, chlordimeform).Most of first and second generation acaricides are not used any longer.

Specific acaricides of the third generation are represented by **mite growth inhibitors** (clofentezine, hexythiazox), commercialized in the first half of the 1980s. Introduction of specific acaricides reduced the adverse impact on beneficial insects (predators of insect and mite pests, polinators) to the minimum; at the same time, many specific acaricides proved to be selective, i.e. less toxic to predaceous mites than phytophagous mites. These acaricides effectively control populations of phytophagous mites resistant to neuroactive compounds, since they are compounds having different biochemical modes of action, with targets mostly being outside the nervous system (March,1976; Knowles, 1976, 1997; Ishaaya, 2001; Krämer & Schirmer, 2007).

In addition to specific acaricides, two new groups of synthetic insecto-acaricides were placed on the market in the 1970s and 1980s: **pyrethroids** (neuroactive compounds, sodium channel modulators) and **benzoylureas** (compounds acting on growth and development by inhibition of biosynthesis of chitin, a biopolymer present in the cuticle of arthropods) (Ishaaya, 2001; Krämer & Schirmer, 2007).

New approaches for controlling Mites:

Development of novel compound affecting specific process such as CSI, JH mimics and Ecdysone agonists. Effort have been made to develop compound acting selectively on groups of mites / insects by inhibiting / enhancing:- Bio-chemical sites : Respiration (diafenthiuron: Pegasus), METI (fenazaquin: Magister),GABA receptor (avamectin:Vertimec).

Abamectin is a neuroactive insecto-acaricide (chloride channel activator), a mixture of macrocyclic lactones avermectin B1a and avermectin B1b, natural products isolated from the fermentation of *Streptomyces avermitilis*, a soil Actinomycete. These compounds increased the biochemical diversity of acaricides and insecto-acaricides, but beside the partly expected resistance, some other problems emerged, such as the pyrethroid-induced spider mite outbreaks.

The search for new chemistries that act on novel target sites and determination of an efficient strategy for use of acaricides that have different biochemical modes of action is presently the only sustainable solution that can prevent or delay the evolution of resistance and prolong the life span of acaricides. Now-a-days, acaricides are developed under conditions marked by growing demand of the public opinion for safer, "greener" pesticides, and increasingly stricter toxicological and eco-toxicological criteria for market circulation of the existing pesticides and registration of the new ones imposed by the regulatory agencies and issues.

Besides re-evaluation of registered pesticides, priority in registration program has been given to "reduced-risk *pesticides*", i.e. pesticides with reduced risk to human health, non-target organisms and environment as a replacement for older and potentially riskier chemicals.

(a) Acaricides acting on respiration targets

Similar to nervous system of insects, nervous system of mites has also long been the target for most chemicals used for their control. The situation has somewhat changed during the last two decades due to commercialization of large number of acaricidal compounds acting on mitochondrial respiration process, that produces most of the energy in cells. This process includes two coupled parts: mitochondrial electron transport (MET) and oxidative phosphorylation. Although some of the older acaricides were known to inhibit respiration, the real exploitation of this target started no sooner than after the 1990s, with the prospects for expanding and developing new, more effective and safer products (Dekeyser, 2005; Lummen, 2007; Krämer & Schirmer, 2007).

Throughout the mitochondrial electron transport chain there are various potential sites for inhibition, but only three have been used so far as target sites of acaricidal activity, at transmembrane enzyme complexes.

In the period 1991-93, four compounds from different chemical classes were successively commercialized: **fenpyroximate** (pyrazole), **pyridaben** (pyridazinone), **fenazaquin** (quinazoline) and **tebufenpyrad** (pyrazolecarboxamide) ,whose mode of action was inhibition of MET at complex I. These compounds, also known as METI acaricides, quickly gained the popularity worldwide owing to the high efficacy against both tetranychid and eriophyoid mites, quick knockdown effect and long-lasting impact (Dekeyser, 2005; Krämer & Schirmer, 2007, van Leewen et al., 2010). In addition, these substances have low to moderate mammalian toxicity and short to moderate environmental persistence. Fenpyroximate is also on the list of reduced risk and organophosphorus alternative pesticides. Complex I inhibitors also include **pyrimidifen** (pyrimidinamine), commercialized in 1995, as well as insecto-acaricide **tolfenpyrad**, another pyrazolecarboxamide, commercialized in 2002, and **flufenerim,** more recent derivative of pyrimidifen .

The only known complex II inhibitor is the recently introduced insecto-acaricide **cyenopyrafen**, a compound from the acrylonitrile class of chemistry .

Complex III inhibition is mode of action of acequinocyl, fluacrypyrim and bifenazate. **Acequinocyl**, a naphthoquinone compound commercialized in 1999, is a proacaricide. **Bifenazate**, a carbazate compound is highly effective against immatures and adults of spider mites, with rapid knockdown effect. Although it was first considered to be a neurotoxin, more recent experimental results indicate complex III as target site. It is also a pro-acaricide. This has been, introduced in 1999, is a compound of low mammalian toxicity and short environmental persistence; it is classified as a reduced risk and organophosphate alternative pesticide. **Fluacrypyrim**, introduced in 2002, shows acaricidal effect against all stages of tetranychids. This is the first strobilurin not commercialized as a fungicide. Insecto-acaricide **diafenthiuron**, a novel thiourea compound launched in 1991, is the only modern representative of compounds that disrupt oxidative phosphorylation by inhibition of the mitochondrial ATP synthase, an enzyme with essential role in cellular bioenergetics. This is a pro-acaricide, its carbodiamide metabolite inhibits the enzyme. It is effective against motile stages of spider mites and also provides good eriophyoid control. Diafenthiuron has low mammalian toxicity and short environmental persistence.

Insecto-acaricide **diafenthiuron**, a novel thiourea compound launched in 1991, is the only modern representative of compounds that disrupt oxidative phosphorylation by inhibition of the mitochondrial ATP synthase, an enzyme with essential role in cellular bioenergetics (this mode of action has been recognized in propargites, tetradifons and organotin compounds). Diafenthiuron is a pro-acaricide, its carbodiimide metabolite inhibits the enzyme. It is effective against motile stages of spider mites and also provides good eriophyoid control(Krämer & Schirmer, 2007; van Leewen et al., 2010).

Another insecto-acaricide, **chlorfenapyr**, a pyrrole compound commercialized in 1995, at biochemical level acts as uncoupler of oxidative phosphorylation via disruption of the proton gradient. It is effective against all stages of spider mites and eriophyoid mites. Chlorfenapyr is a compound of moderate mammalian toxicity, but long environmental persistence (Krämer & Schirmer, 2007; Van Leeuwen et al., 2010).

(b) Acaricides acting on growth and development targets :

Another direction in research and development of synthetic acaricides is directed towards compounds affecting developmental processes. **Etoxazole,** a oxazoline compound , is acaricide highly effective against eggs and immatures of spider mites (Kim & Yoo, 2002; Dekeyser, 2005), non-toxic to adults, but it considerably reduces fertility of treated females. This acaricide, launched in 1998, is usually classified among mite growth inhibitors, together with clofentezine and hexythiazox, older acaricides that cause similar symptoms , but whose exact mode of action is unknown (Marcic,2003; Krämer & Schirmer, 2007). Etoxazole acts as a chitin synthesis inhibitor similar to benzoylureas and is on the EPA list of reduced risk and organophosphorus alternative pesticides (EPA, 2009).

Discovery of **spirodiclofen** and **spiromesifen,** tetronic acid derivatives launched in 2002-2004, broadened the biochemical diversity of acaricides by introducing a completely new mode of action. These compounds act as inhibitors of acetyl-CoA-carboxylase, a key enzyme in fatty acid biosynthesis. Spirodiclofen and spiromesifen are highly toxic to eggs and immatures of spider mites, while their effects on adult females are slower with fecundity and fertility reduction; their acaricidal effect is long-lasting and stable (Van Pottelberge et al., 2009; Marcic et al.,2010). These two acaricides are the only new compounds used for control of eriophyoid mites as well. while spiromesifen provides effective control of whiteflies. Both compounds have low mammalian toxicity and short environmental persistence.

Spirotetramat, a tetramic acid derivate recently introduced, belongs to inhibitors of acetyl-CoA-carboxylase. Although initially developed for control of whiteflies and aphids (Brück et al., 2009), the studies of its effects on *T. urticae* indicate that spirotetramat could potentially be an effective acaricide as well.

(c) Natural acaricides and other alternative solutions :

The use of natural products for plant and crop protection dates back to times long before the introduction of synthetic pesticides which imposed themselves as the main means for suppression of harmful organisms. In recent times, the significance of natural pesticides is constantly growing, primarily in organic agriculture, but also in the framework of biorational pest control programs which insist on use of environmentally-friendly pesticides and exploatation of novel biochemical modes of action (Isman, 2006; Isman & Akhtar, 2007; Copping & Duke, 2007; Horowitz et al., 2009). Some of the natural products are substances that have significant acaricidal effect. Probably the most studied botanical insecticide in the last twenty years is a triterpenoid **azadirachtin,** the major active ingredient of extracts, oils and other products derived from the seeds of the Indian neem tree (*Azadirachta indica*). Neem-products are registered in over 40 countries as products for suppression of arthropod pests important in growing of fruit, vegetables and ornamental plants (Kleeberg, 2004; Milenkovic et al., 2005).

Products isolated from soil actinomycetes are an important source for deriving natural insecticides and acaricides. In early 1990s, several years after introduction of abamectin, another fermentation product, **milbemectin,** was commercialized. Milbemectin is a mixture of milbemycin A3 and milbemycin A4, natural products isolated from the fermentations of *Streptomyces hygroscopicus* subsp. *Aureolacrimosus.* Milbemectin is a neuroactive acaricide (chloride channel activator), effective against tetranychid and eriophyoid mites, relatively safe compound owing to the rapid uptake into treated plants combined with fast degradation of surface residues (Copping & Duke, 2007; Krämer & Schirmer, 2007). The more recent example is **spinosad,** a mixture of spinosyn A and spinosyn D, secondary metabolites of *Saccharopolyspora spinosa*, introduced in 1997 as neuroactive insecticide, nicotinic acetylcholine receptor agonist (Copping & Duke, 2007; Krämer & Schirmer, 2007). This insecticide exerts significant acaricidal effect. This is a compound of very low mammalian toxicity and highly favourable environmental profile. This insecticide exerts significant acaricidal effect. Van Leeuwen et al. (2005)found out that the residual toxicity of spinosad to female *T. urticae* is equal to the level oftoxicity resulting from application of dicofol, bromopropylate or fenbutatin oxide, while Villanueva & Walgenbach (2006) demonstrated that spinosad affects larvae and adults of this tetranychid, but relatively slowly, with the assumption that negative results of the previous testing of acaricidal properties were based on experiments that did not provide enough time for response. Thisis a compound of very low mammalian toxicity and highly favourable environmental profile; it is included in the EPA list of organophosphorus alternative pesticides, and also in Annex I (EPA, 2009; EU, 2010). Spinosad is approved for use as an organic insecticide (EU, 2008; Dayan et al., 2009).

Conclusion :

World-wide, IPM has become the accepted model for vegetable protection over the past decades, but the adoption of IPM programs has been generally slow in both the developed and the developing countries (Peshin et al., 2009). Success of IPM has often been measured by the reduction in pesticide usage, which is not necessarily a reliable indicator (Kogan, 1998). Transition from conventional pest control to IPM actually changes the role of pesticides (acaricides) in modern crop protection: within the principles of IPM, pesticides are applied highly rationally and in interaction with other control tactics.

References :

1. Anonymous, 1991, Mites of agricultural importance in India and their management.
2. Anonymous, 2001, *Horticultural Crop Statistics of Karnataka State at a glance 2000 – 01*. Department of Horticulture, Government of Karnataka, Bangalore p.115.
3. Anonymous, 2005, *The Hindu ,Survey of Indian Agriculture*, pp. 147 – 148. *Bioorganic and Medicinal Chemistry*, 17, 12, 4022-4034, ISSN 0968-0896.
4. Brück, E.; Elbert, A.; Fischer, R.; Krueger, S.; Kühnhold, J ; Klueken A.M.; Nauen, R.; Niebes, J.F.; Reckman, U.; Schnorbach, J.J.; Steffens, R. & van Waetermeulen, X. (2009). Movento®, an innovative ambimobile insecticide for sucking insect pest control in agriculture: biological profile and field performance. *Crop Protection*, 28, 10, 838-844,
5. Channabasavanna, G. P. 1966, A contribution to the knowledge of Indian eriophyid mites (Eriophyoidea : Trombidiformes, Acarina). *University Science Bulletin*, Bangalore, p. 153. 6.Copping, L.G. & Duke, S.O. (2007). Natural products that have been used commercially as crop protection agents – a review. *Pest Management Science*, 63, 6, 524-554, ISSN
7. Dayan, F.E.; Cantrell, C.L. & Duke, S.O. (2009). Natural products in crop protection. *Bioorganic and Medicinal Chemistry*, 17, 12, 4022-4034, ISSN 0968-0896
8. Dekeyser, M.A. (2005). Acaricide mode of action. *Pest Management Science*, 61, 2, 103-110, ISSN 1526-498X. Dordrecht, the Netherlands.
9. EPA (2009). Reduced Risk/Organophosphate Alternative Decisions for Conventional Pesticides. www.epa.gov/opprd001/workplan/completionsportrait.pdf
10. EU (2008). Comission Regulation (EC) No 889/2008. *Official Journal of the European Union*, 51, L 250, ISSN 1725-2555.
11. EU (2010). EU Pesticide Database: http://ec.europa.eu/sanco_pesticides/public/index.cfm (Accessed July 31, 2010).
12. Grandjean, F., 1948, Quelques carders des tetranyques *Bull. Museum Naturelle,*Paris, **2** : 517 – 524. grown in rockwool. *Expt. Appl.Acarol.*, 37, 1, 93-105, ISSN 1572-
13. Gupta, S. K., 1991, The mites of agricultural importance in India with remarks on their economic status In: *Modern Acarology*, (*Eds*. Dushabek, F. and Bukva, U.), Academic Press, Hague, pp. 509 – 522.
14. Horowitz, A.R.; Ellsworth, P.C. & Ishaaya, I. (2009) Biorational Pest Control – An Overview, *In*: *Biorational Control of Arthropod Pests*, Ishaaya, I. & Horowitz, A.R (ed.), 1-20, Springer, ISBN 978-90-481-2315-5, Dordrecht, the Netherlands.
15. Huffaker, C. B., Vande vrie, H. and Mcmurtry, J. A., 1969, The ecology of tetranychid mites and their natural control. *Ann. Rev. Entomo.l,* **14**: 125 – 174. *In*:Ishaaya, I.; Nauen, R. & Horowitz, R (ed.), 197-215, Springer-Verlag, ISBN 10: 3- ISBN 10: 3-540-46904-4, Berlin, Heidelberg

16. Ishaaya, I. (2001). Biochemical Sites of Insecticide Action and Resistance. Springer-Verlag, ISBN 3-540-67625-2, Berlin, Heidelberg and New York.
17. Isman, M.B. & Akhtar, Y. (2007). Plant Natural Products as a Source for Developing
18. Isman, M.B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Ann.Rev.. Entomol.*, 51, 45-66, ISSN 0066-4170. ISSN 0261-2194.
19. Jeppson, L. R., keifer, H. H , and Baker, E. W. 1975, *Mites·Injurious to EconomicPlants.* University of California Press, Barkeley, p 614.
20. Kim, S.S. & Yoo, S. (2002). Comparative toxicity of some acaricides to the predatory mite, *Phytoseiulus persimilis* and the twospotted spider mite, *Tetranychus urticae.BioControl*, 47, 5, 563-573, ISSN 1386-6141.
21. Kleeberg, H. (2004). Neem based products – registration requirements, regulatory processes and global implications. *In: Neem, Today and in The New Millenium*, Koul O. & Wahab S. (ed.), 109-123, Kluwer Academic Publishers, ISBN-10: 1402012292, 22. Knowles, C.O. (1976). Chemistry and toxicology of quinoxaline, organotin, organofluorine, and formamidine acaricides. *Environmental Health Perspectives*, 14, 93-102, ISSN 0091-6765.
23. Knowles, C.O. (1997). Mechamisms of resistance to acaricides, *In*: *Molecular Mechanisms of Resistance to Agrochemicals*, Sjut, V. & Butters, J.A. (ed.), 58-78, Springer Verlag, ISBN 3-540-62461-9, Berlin – Heidelberg.
24. Kogan, M. (1998). Integrated pest management – historical perspectives and contemporary developments. *Ann. Rev. Entomol.*, 43, 243-270, ISSN 0066-4170.
25. Krämer, W. & Schirmer, U. (2007). *Modern Crop Protection Compounds, Vol. 3,* WILEY – VCH Verlag GmbH & Co., ISBN 978-3-527-31496-6, Weinheim, Germany.
26. Krämer, W. & Schirmer, U. (2007). *Modern Crop Protection Compounds, Vol. 3,* WILEY – VCH Verlag GmbH & Co., ISBN 978-3-527-31496-6, Weinheim, Germany.
27. Lümmen, P. (2007). Mitochondrial electron transport complexes as biochemical target sites for insecticides and acaricides, In: *Insecticide Design Using Advanced Technologies,* Management. a Global Overview of History, Programs and Adoption. *In*: *Integrated.*
28. March, R B. (1976). Properties and actions of bridged diphenyl acaricides. *Environmental Health Perspectives*, 14, 83-91, ISSN 0091-6765.
29. Marčić, D. (2003). The effects of clofentezine on life-table parameters in two-spotted spidermite *Tetranychus urticae. Expt. Appl.Acarol*, 30, 3, 249-263, ISSN 1572-9702.
30. Marčić, D., Ogurlić. I.; Mutavdžić, S. & Perić, P. (2010). The effects of spiromesifen on life history traits and population growth of two-spotted spider mite (Acari:Tetranychidae). *Expt. Appl.Acarol*, 50, 3, 255-267, ISSN 1572-9702.
31 Milenković, S., Tanasković, S. & Lazic, T. (2005) [Azadirachtin – the possibilities of use in plant protection]. *Voćarstvo*, 39, 1, 61-69, ISSN 1820-5054 (in Serbian).
32 Peshin, R.; Bandral, R.S.; Zhang, W.J.; Wilson, L. & Dhawan, A. (2009). *Integrated Pest Pest Management: Innnovation-Development Process*, Peshin, R & Dhawan, A.K. (ed.),
33. Singhal, V., 2003, *Indian Agriculture.* Vikas Publishing House Pvt. Ltd., New Delhi, pp. 150 – 153.*Technology Bulletin No. 1.* All India Coordinated Research Project on Agricultural Acarology, UAS, Bangalore, p.18

34. van Leeuwen, T.; Dermauw, W.; van de Veire, M. & Tirry, L. (2005a). Systemic use of spinosad to control the two-spotted spider mite (Acari: Tetranychidae) on tomatoes *Technologies*, *In*: Ishaaya I.; Nauen R. & Horowitz R. (ed.), 235-248, Springer-Verlag, *Tetranychus urticae* and *Panonychus ulmi* (Acari: Tetranychidae). *Jr. econ.Entomol.*, 99, 3, 843-849, ISSN 0022-1493.
35. van Leeuwen, T.; Witters, J.; Nauen, R.; Duso, C. and Tirry, L. (2010). The control of eriophyoid mites: state of the art and future challenges. *Exp. Appl.Acarol.*, 51, 1-3, 205-224, ISSN 1572-9702
36. van Pottelberge, S.; van Leeuwen, T.; Nauen, R. & Tirry, L. (2009). Resistance mechanisms to mitochondrial electron transport inhibitors in a field-collected strain of *Tetranychus urticae* Koch (Acari: Tetranychidae). *Bull. Entomol. Res.*, 99, 1, 23-31, ISSN 0007-4853.
37. Villanueva, R.T. & Walgenbach, J.F. (2006). Acaricidal properties of spinosad against *Tetranychus urticae* and *Panonychus ulmi* (Acari: Tetranychidae). *Jr. Econ.Entomol.*, 99, 3, 843-849, ISSN 0022-1493.

WEED MANAGEMENT IN VEGETABLE CROPS

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Introduction :

Vegetables play a major role in terms of food, nutritional and economic security and more importantly, producing higher returns per unit area and time. In addition, vegetables have higher productivity, shorter maturity cycle, high value and provide greater income, leading to improved livelihoods. There has been an overall growth rate of 2.08% in area, 1.64% in productivity and 3.72% in total production of vegetables during last five years in India. However, West Bengal is the highest producer of vegetables among different states in the country. Diverse agro-climatic zones in the country including the state of West Bengal permit growing of several vegetables round the year. Common vegetables in the state are potato, tomato, cabbage, cauliflower, radish, carrot, pea, brinjal, onion, garlic, ladies' finger (okra), cucurbits (gourd, cucumber, bitter gourd, bottle gourd, sponge gourd, pointed gourd, squash), French bean, leafy vegetables (spinach, amaranthus, *Ipomoea*), elephant's foot yam, taro (colocasia), turnip, beet, brussels sprout, tapioca, etc. Out of these, the important ones are potato, tomato, onion, brinjal, cabbage, cauliflower and okra. Despite these, still there is a huge gap between present production and future requirements not only in the state but also in the country as a whole. The major challenge ahead is to develop technologies that enhance quality and productivity of vegetables under reducing land, declining natural resources and increasing biotic and abiotic stresses (Naik, 2013). One of the major constraints in vegetable production is the problem of crop pests, of which weeds are the important one. So far as crop-weed competition is concerned, vegetables are poor competitors for their slow initial growth, less plant density due to wider spacing and short stature. Root vegetables sometimes get affected, resulting in poor and thin size, shape etc. due to severe weed competition. All these call for a sound weed management practice in vegetable cultivation.

LOSSES IN YIELD AND QUALITY:

Yield loss due to weeds depends on the nature of weed flora, intensity of infestation, types of crops and varieties, cultural practices followed and obviously on climatic conditions or growing season. Considering these factors, the yield reduction in different vegetable crops has been reported to be up to 50% in potato, 25-35% in peas, 70-80% in carrot, 40-80% in onion, 70-75% in tomato, 60% in cabbage and cauliflower, and 60-70% in cucurbits.

Weeds not only reduce the economic yield in vegetables but also impair the quality of crop seeds, especially in vegetable seed production, by weed seed admixture / contamination. Many weeds act as alternate or alternative hosts of insect pests and pathogens. For example, *Solanum nigrum* is a host for brinjal fruit and shoot borer. Common lambsquarters (*Chenopodium album*) acts as alternative host for aphids. *Ageratum conyzoides* and *Lantana camara* are the shelter of white fly which transmits yellow vein mosaic virus disease. *Parthenium*, which is now reported in many vegetables, acts as host for insect *Ferrisia consorbina*. Thus, weeds directly or indirectly cause reduction in yield and quality of produce in vegetables.

CRITICAL PERIOD OF CROP-WEED COMPETITION:

Weeds in vegetables should be managed effectively in early stage of crop growth. There is certain critical period for each vegetable crop, where and when weed management results in maximum benefit (Table 1). Almost all the vegetables grow slowly during initial stage which has been attributed for their poor competition with weeds unlike many other arable crops. Generally first one-third of the life cycle of crop is considered as critical period in most of the vegetables. But practically this is variable and depends on crop variety, growth rate, plant density and geometry, growing season, and nature and intensity of weed infestation.

Table 1. Critical period of crop-weed competition in some vegetable cropsa

Crop	Critical period
Potato / Radish	25-45 DAS
Onion / Garlic	30-75 DAS
Tomato / Chilli	30-60 DAS
Cabbage / Cauliflower	30-45 DAS
Okra	20-60 DAS
Brinjal	20-60 DAS
Carrot	15-30 DAS

DAS: Days after sowing

[a]Modified from Singh *et al.* (1993)

METHODS OF WEED MANAGEMENT :

1. Preventive:

Prevention is better than cure. It is true for weed management in vegetable crops. Prevention encompasses all measures taken to check entry and further spread. Care should be taken to prevent the entry of weeds in vegetable fields in following ways:

(a) Use of weed seed free clean seed of crop for planting;
(b) Use of well decomposed organic matter free from weed seeds;
(c) All the weeds present in irrigation channels, ditches, fence rows and nearby non-cropped areas should be removed and cleaned;
(d) Nursery stock or seedlings should be carefully inspected for any weed seeds or propagules;
(e) Tillage and sowing implements should be cleaned and washed before moving from one field to another.

2. Cultural (Agronomic practices) :

Cultural method of weed management in vegetables exploits the crop's behavior, growing environment and crop management practices towards smothering of weeds. A good crop is the best weed killer and hence, good crop husbandry should be followed. Every practice needs to be adopted with due care and should result in or aim at boosting up of initial growth of crops. Establishing a good crop stand in which plants emerge and rapidly shade the ground is an often overlooked tool for reducing weed competition. The plant that emerges first and grows most rapidly has the competitive advantage. Good production management practices such as fertility, well-adapted varieties, proper water control (irrigation, drainage), and establishment of adequate plant population, are very helpful in reducing weed competition. Everything possible should be done to ensure that the crop—not the weeds—has the competitive advantage.

(a) Land selection : A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially of perennial weeds.

(b) Crop selection : One criterion in selecting a crop should be the weed problems of the field. Weed competitive crops are to be planted in the most weed-infested fields and the least competitive crops in the cleanest ones.

(c) Stale seed bed technique : It is very effective method of weed management in vegetables. Seedbeds are prepared about two weeks before the planting of crops. The weeds are allowed to grow and a green mat of weeds will be formed. The flush of weeds are destroyed with herbicides like paraquat or glyphosate. Sowing or transplanting is done with minimum soil disturbances, resulting in very few weed germination during the season. This is very effective in vegetable nursery also.

(d) Crop rotation : Another very effective means of reducing weed problems in vegetable crop is crop rotation. The characteristics of the crop and the component technology including the herbicides used can suppress some weeds and inadvertently allow certain weeds to escape control. Rotating between crops improves growth and the crops' competitiveness. Related vegetables should not be grown in the same location in successive years. Some of the related vegetables are muskmelon, pumpkin, water melon, squash among cucurbits; garlic and onion among onion groups; potato, tomato, chilli, capsicum, brinjal etc. among solanaceous group; beet and spinach among spinach group; beans, pea among beans group; cabbage, cauliflower and radish among crucifers. Rotation also breaks the association of specific weed and crop. Orobanche infestation in tomato, brinjal etc. may be avoided by the practice of crop rotation, avoiding solanaceous crops in rotation.

(e) Closure planting, proper plant density and adjusting time of sowing /

planting : Growing vegetables with narrower row spacing and proper plant densities assure that the crop rapidly closes canopy. A closed canopy shades out later-emerging weeds. Weeds become less problematic after the canopy coverage of crop. Proper row spacing and plant density also allow row cultivation. Another cultural method to improve crop competitiveness is to use the correct planting time. The planting date affects the time to emergence and early seedling vigor of the crop, which are important in determining crop competitiveness.

(f) Nutrient and pest management : Adequate fertilization and appropriate insect and disease management are important in assuring a competitive crop. Adequate fertility assures rapid, uniform germination and good crop growth, which enhance the crop's competitive ability. While poor insect and disease control reduce a crop's competitiveness, inadequate weed control can also cause insect and disease problems.

(g) Method and time of irrigation : In most of the vegetable crops grown in row, furrow irrigation is applied. But drip irrigation facilitates lower weed infestation than furrow irrigation due to wetting of soil near the root zone of the crop and rest of the areas remain dry and free of weeds. Similarly in alternate furrow irrigation methods, weed infestation is less. Again it should always be remembered that pre-sowing irrigation is always better than sowing in dry condition followed by irrigation. Because, pre-sowing irrigation facilitates weed seeds to germinate and their subsequent destruction during land preparation.

(h) Mulching : Mulching can be useful in managing weeds. Mulches may be classified as either natural (straw, leaves, paper, and compost) or synthetic (plastic). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 4 cm thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough that they are not easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil. In case of potato, brinjal, tomato, onion, garlic, chilli etc., crop residues like rice straw and husk, and weeds like water hyacinth, railway creeper and other mulches are successfully used for weed control besides for retention of soil moisture. The plant materials should be chopped into pieces and spread within the crop rows before weed emergence.

(i) Solarization : It is a method of raising soil surface temperature by using transparent polythene (polyethylene) sheet placed on moist soil. The process will raise the temperature by 8-12°C as compared to untreated soil. During summer month (April-June) soil solarization for 4-6 weeks using thin plastic film (50-100 μ thickness) before sowing is very effective for weed management in vegetable nursery as well as in main field. Many annual weeds except Melilotus spp., some perennials and parasitic weeds are sensitive to this treatment. In addition to control weeds and soil-borne pathogens, soil solarization also enhances the availability of nutrients in soil and favours beneficial microflora, resulting in better growth of crops.

3. Physical (manual and mechanical) :

Hand weeding is the most widely practiced method of weed management in vegetable crops. In most of the cases, it is done by using khurpi (hand hoe). This method is very effective in managing annual weeds. But recently the non-availability of labourers during peak period of field operation has been a big problem for hand weeding. Hand hoeing is also a post-planting intercultural operation in most of the vegetables grown in row / line sowing. Manual or mechanical weeding is generally suggested for two times at 15-20 and 35-40 days after sowing / transplanting / planting (DAS / DAT / DAP) Wheel hoe and various types of mechanical weeders are effective alone or in combination with herbicides.

4. Chemical :

Herbicides have been indispensable in many crops due to several reasons. Even herbicides become obvious choice to the farmers because of non-availability of labourers, higher wage rate, absence of suitable weed control implements etc. However, chemical weed management in vegetables is poorly developed. Though many herbicides initially developed for other crops are used in vegetables, the choice of specific selective herbicides in vegetables is limited. Herbicides recommended for major vegetables are given in Table 2.

Table 2. Selective herbicides for weed management in vegetable cropsb

Herbicides	Dose (g a.i. ha-1)	Application time	Remarks
Potato			
Pendimethalin	1000	Pre-emergence	To be applied at 2-3 DAP. Moisture in soil is essential for activity. Controls many annual grasses and some broadleaves.
Metribuzin	400	Pre-emergence or early post-emergence	To be applied as pre-emergence at 1-3 DAP or as post-emergence at 15-20 DAP.
Paraquat dichloride	500	Post-emergence	At 2-7% sprouting of potato. Controls all weeds.
Isoproturon	750-1000	Pre-emergence or early post-emergence	Controls wide variety of annual weeds.

Butachlor	750-1000	Pre-emergence	To be applied within 3-4 DAP. Ensure adequate soil moisture at the time of application.
Fluchloralin	1000-1500	Pre-planting	To be incorporated into the surface soil immediately after application.
Prometryne	1000-2000	Pre-emergence	Controls annual broadleaved and some grasses. Sufficient soil moisture is to be ensured.
Oxyfluorfen	100	Pre-emergence	Controls all weeds including *S. nigrum* and other weeds tolerant to metribuzin.

Cauliflower / Cabbage / Knolkhol

Fluchloralin	1000	Pre-or post-transplanting	To be incorporated into the surface soil immediately after application or be applied just before planting followed by irrigation.
Pendimethalin	1000	Pre-or post-transplanting	To be applied before or immediately after transplanting followed by irrigation. Controls many annual grasses and some broad leaf weeds.
Oxyfluorfen	200	Pre-emergence and before or after transplanting	All weeds
Quizalofop-p-ethyl	50	Post-emergence	Kills many grassy weeds.
Fenoxaprop-p-ethyl	60	Post-emergence	Kills many grassy weeds.
Tomato / Brinjal / Chilli / Green Pepper			
Alachlor	2000	Pre-transplanting	To be applied before transplanting followed by irrigation.

Fluchloralin	1000	Pre-transplanting	To be applied before transplanting followed by irrigation.
Pendimethalin	1000	Pre- or post transplanting	To be applied before or immediately after transplanting followed by irrigation. Controls many annual grasses and some broad leaf weeds.
Quizalofop-p-ethyl	50	Post-emergence	Kills many grassy weeds.
Metribuzin (in tomato)	500	Pre-transplanting or early post-emergence	To be applied one week before transplanting followed by irrigation or post-emergence at two weeks after transplanting. Could be applied as early post-emergence by avoiding direct contact with tomato plants.
Oxadiazon (in chilli)	500-750	Pre-transplanting	Controls many annual grasses and some broad leaf weeds.
Onion / Garlic			
Butachlor	1000-1250	Post-transplanting	To be applied within 3-4 DAT either before or after irrigation.
Fluchloralin	1000	Pre-or post-transplanting	To be applied before or after transplanting and followed by irrigation. Controls many annual grasses and some broad leaf weeds.
Haloxyfop-butyl	100	2 weeks after transplanting	To be applied when maximum weeds have emerged. Gives excellent control of grasses and some sedges, but poor on broad leaf weeds.
Oxadiargyl	90	0-3 DAT	To be applied before weed emergence and after irrigation. Gives excellent control of grasses and some sedges.
Oxadiazon	500-750	Pre- or post-transplanting	To be applied before or after transplanting and followed by irrigation.

Oxyfluorfen	250	Pre- or early post-transplanting	To be applied before or after transplanting and followed by irrigation.Controls many annual grasses and some broad leaf weeds. Could be applied up to 25-30 DAT.
Pendimethalin	1000	Pre- or post-transplanting	To be applied before or after transplanting and followed by irrigation. If direct sown, spray within 2-3 DAS.
Quizalofop-p-ethyl	50	Post-emergence	Kills many grassy weeds.
Beet Root / Radish / Carrot / Sugarbeet			
Fluchloralin	1000	Pre-planting or Pre- or post-transplanting	Controls many annual grasses and some broad leaf weeds.
Pendimethalin	1000	0-3 DAS or Pre- or post -transplanting	To be applied at 0-3 DAS in case of direct seeded crop. Controls many annual grasses and some broad leaf weeds.
Quizalofop-p-ethyl	50	Post-emergence	Kills many grassy weeds.
Fenoxaprop-p-ethyl	60	Post-emergence	Kills many grassy weeds.
Cucurbits			
Fluchloralin	1000	Pre-planting	To be incorporated into the surface soil immediately after application.
Pendimethalin	1000-1500	Pre-emergence	To be applied at 2-3 DAS. Controls many annual grasses and some broad leaf weeds.
Quizalofop-p-ethyl	50	Post-emergence	Controls many grassy weeds.
Oxyfluorfen	250	Pre-emergence	Precautions to be taken during spray on soil surface to avoid direct contact of seedlings or seeds.

Metribuzin	500	Pre-emergence	Precautions to be taken during spray on soil surface to avoid direct contact of seedlings or seeds. Controls many annual grasses and some broad leaf weeds.

DAP: Days after planting; DAS: Days after sowing; DAT: Days after transplanting
[b]Modified from Dixit and Varshney (2009), Mondal et al. (2005), Hossain et al. (2009), Das et al. (2012) and Kodandaram et al. (2013).

It is evident from the list of herbicides given in Table 2 that pendimethalin is quite effective in all the vegetables. In fact, it can be applied in more than 40 crops (Das and Duary, 1998). In case of colocasia, application of oxyfluorfen at 200 g a.i. ha^{-1} is quite effective in managing weeds for more than 45 days (Duary, 2013). Combination of pre-planting application of glyphosate at 2.5-3.0 liter ha^{-1} and oxyfluorfen at 100 g a.i. ha^{-1} in wide spaced crops like cucurbits remains quite effective for longer period of time. To manage the weed infestation in *kharif* crop of okra, application of metolachlor at 1.0 kg ha-1 has been found to be cost-effective. Vegetable cultivation is to be avoided in the fields that are severely infested with nutsedge, hard-seeded legumes, or other difficult-to-control weeds. Many weed problems can be reduced by preparing the land well ahead of planting and using glyphosate in a "cropping system" approach, and/or using paraquat in a "stale seed bed" approach.

5. Integrated weed management :

No single method will be adequate, economic and effective in vegetable crops. Good crop husbandry along with pre-emergence herbicide application should be followed by at least one inter-cultivation or mechanical weeding. Integrated use of pre-planting application of glyphosate followed by mulching or one hand weeding / mechanical weeding is very effective in most of the vegetable crops. Many difficult to control weeds like *Cyperus rotundus* and parasitic weeds like *Orobanche* should be managed by an integrated approach using herbicide, cultural like soil solarization or crop rotation, and preventive methods.

CONCLUSION :

Weed problem in vegetable crops is rather more serious than field crops which may be due to their more requirements for nutrients and water. Many farmers generally use to add farm yard manure in raw form in the fields meant for vegetable cultivation and this practice aggravates weed problems. In addition, frequent irrigations allow weed seeds to germinate and appear in many flushes. Moreover, wider spacing leaves more area at the disposal of weeds. Even most of the vegetable crops, especially during critical periods of crop-weed competition, do not provide effective crop canopy to suppress weed growth. Managing the weeds in early stages is imperative as initial growth of most of the vegetable crops is very slow that encourages germination, growth and development of weed seedlings. Furthermore, weed management requires a multifaceted approach, involving non-chemical methods, chemical methods (herbicides), or a judicious combination of the two, depending on environmental concerns, marketing opportunities, desired management intensity, labour availability, weed pressure, and the vegetable crop. While using herbicides, they should have no residual toxicity as many vegetables are often consumed afresh.

REFERENCES :

Das, T. K. and Duary, B. 1998. Pendimethalin- an excellent herbicide for weed control in crops. *Intensive Agriculture* **36** (5-6): 18-20.

Das, T. K., Tuti, M. D., Sharma, R., Paul, T. and Mirjha, P. R. 2012. Weed management research in India: An overview. *Indian Journal of Agronomy* **57** (3rd IAC Special Issue): 148-156.

Duary, B. 2013. Personal communication (Unpublished paper). Department of ASEPAN, Institute of Agriculture (Palli Siksha Bhavana), Visva-Bharati, Sriniketan, Birbhum, West Bengal, India,

Dixit, A. K. and Varshney, J. G. 2009. *Herbicide use in field crops*. Directorate of Weed Science Research (ICAR), Jabalpur, Madhya Pradesh, India.

Hossain, A., Duary, B. and Mondal, D. C. 2009. Studies on weed flora of okra and its management in the lateritic zone of West Bengal. In: *Abstracts of National Symposium on Weed Threat to Environment, Biodiversity and Agricultural Productivity,* August 2-3, 2009, Indian Society of Weed Science at Tamil Nadu Agricultural University. p. 48.

Kodandaram, M. H., Saha, S., Rai, A. B. and Naik, P. S. 2013. *Compendium on pesticide use in vegetables*. IIVR Extension Bulletin No. 50, Indian Institute of Vegetable Research (ICAR), Varanasi 221 305, Uttar Pradesh, India. pp. 133.

Mondal, D. C., Hossain, A. and Duary, B. 2005. Chemical weed control in onion (*Allium cepa* L.) under lateritic belt of West Bengal. *Indian Journal of Weed Science* **37**(3&4): 281-282.

Naik, P. S. 2013. Director' message. Indian Institute of Vegetable Research (ICAR), Post Bag No. 01, Jakhini (Shahanshapur), Varanasi 221 305, Uttar Pradesh, India. Available at: http://www.iivr.org.in/Announcement.aspx (Accessed on: September 05, 2013).

Singh, K., Pandita, M. L. and Thakral, K. K. 1993. Integrated weed management in vegetable crops. In: *Proceedings International Symposium of Indian Society of Weed Science,* Hisar, Haryana, Nov. 18-20, 1993, Vol 1. pp. 365-368.

VEGETABLE DISEASE MANAGEMENT WITH BIORATIONAL PEST CONTROL AGENTS

Jayanta Tarafdar

Diversification,intensification and globalization of agriculture add to emergence of diseases caused by virus, bacteria, and fungal pathogens which causing increase in disease incidence, aggressive in pathogenecity and host range which may be mainly driven by pathogen introduction through germplasm exchange, trade in plant products, seeds, planting materials and live plants. The unusual weather events also have been linked to the global changes in relates to plant diseases. The emerging disease outbreaks involving plants around the world are buffeted by several re-emerging viruses, fungi and few bacteria. Of three thousand edible plant species only 12 species of grain crops, 23 vegetable crops and 35 fruits are grown. The latest available data suggest that pre-harvest pest and disease damage in the eight most important food and cash crops accounts for ~42% of the attainable crop production or a production value of >US$300 billion. In the recent report, losses due to plant health problems occur to the extent of 43% in developing countries in Asia.

For vegetable crop, India leads a major position in the world and the state, West Bengal is the 2nd largest vegetable producer in India with the area about 12.10 lac hectors and contributes a good share of production of all the vegetable crops. But several conditions like a susceptible host plant, a pathogenic organism, a good method of distributing the organism, and the proper environment support the pathogenic organisms to exist, enter the plant, and thrive. The increasingly wider distribution and higher population levels of the insect vectors are directly implicated in the development of epidemics of several viral diseases specially Gemini viruses in vegetable agroecosystems. When the congenial weather conditions are met, infection occurs, and a pathogen becomes established. Incidence of several fungal, bacterial and viral diseases in most of the vegetables crops are the major threats for its cultivation. However, the choice of a proper management tactic must be based on accurate knowledge of the pathogen causing the disease; its life cycle; time of infection; the part of the plant involved; the method of agent distribution; past, present, and future environmental conditions; and certain economic considerations. Effective management may be taken up to combat the diseases which include use of resistant varieties; use of disease free planting materials and clean seed, either certified or grown in disease-free areas; treatment of seed with heat or chemicals; control of insects and weed hosts; monitoring of weather conditions; use of biological control agents; and proper timing and application of fungicides and ecofriendly insecticides. Effective management of vegetable and other horticultural crops diseases requires preventing disease or, if this is not feasible, slowing the spread of disease once it occurs. But much attention may be given to use modern techniques for detection and diagnosis of pathogens and resurgence of the new viruses and its strains.

Diagnosis of Disease :

The first step in disease management should be accurate diagnosis. It is important to differentiate between infectious diseases (e.g. those caused by fungi, bacteria, viruses, and nematodes that can spread from plant to plant) and noninfectious diseases or disorders (e.g., damage caused by mites and insects, physiological disorders, air pollutants, nutrient imbalances, and herbicide injury). Growers who have a reasonably good understanding of plant diseases, their symptoms, and the infectious and noninfectious disorders that can affect a particular crop, are more likely to make the correct disease control decisions.

Disease Management Tactics :

Successful control of vegetable diseases requires an integrated program that includes the use of resistant varieties, crop rotation, balanced soil fertility, weed and insect control, and proper crop culture, as well as the proper selection, timing, and method of applying fungicides, bactericides, or insecticides/ nematicides.

Cultural Practices :

Manipulation of cultural practices, cropping sequence, crop rotation, use of resistant varieties, planting of good seeds and planting materials free from pathogen contamination are the primary options for elimination of the diseases in the particular crops. Choices of unrelated crops to be rotated include beans to sweet corn, leafy vegetables to cucurbits, cucurbits to crucifers, and crucifers to sweet corn. Other pathogens have such a wide host range that they can survive indefinitely because so many crops and weed species serve as hosts. These pathogens include Sclerotium rolfsii, Sclerotinia, Rhizoctonia solani, Verticillium and root-knot nematodes. Many pathogens can overwinter successfully in association with plant debris and are unable to survive once the crop residue decomposes. Destruction of crop residues, deep tillage, and destruction of weeds can eliminate reservoirs of the pathogen propoagules in many of the vegetable crops. Fall tillage is important because it reduces the amount of inoculum that survives the winter.

Cultivation of Diseaseresistant Varieties :

The use of disease-resistant varieties is the most important and ecofriendly approach and reliable methods of disease control. Although resistant varieties are not available for all diseases of vegetable crops, this option should be used whenever possible. Cultivation of disease resistant varieties of vegetable crops also reduces the use of fungicides. But very few varieties of vegetable crops have been released so far and some hybrid varieties of tomato, chilli, cucurbits, gourds, okra, root and tuber crops, beans and cauliflowers and cabbage, brinjal and other leafy vegetables are available for high yielding and other traits which show differential field response to several diseases.

Biological control :

Many researchers have demonstrated that some beneficial fungi, bacteria and actinomycetes show activity against specific fungal pathogens. Some of these organisms have been commercialized and are now available in the marketplace. The biocontrol agents like Trichiderma viridae, T. harzianum, Pseudomonas florescence are widely used in many vegetable crops for controlling soil and seed borne diseases. These products can be quite effective when used properly and offer several advantages including lessened environmental impact and increased worker safety. Often, biocontrols work more slowly and must be used in combination with other control techniques to be effective.

Chemical Control :

The soil borne pathogens like root/stem rot, damping off vegetable crops in nursery beds and in the main field are difficult to control without proper fungicidal treatments. Besides many diseases like Phytophthora blights/rot, wilts, anthracnose, early blights, leaf spots, die-back could be veryeffectively controlled by using prophylactic and curative chemicals sprays. Because many disease problems originate withseeds or transplants, growers should follow the seed-treatment and foliar sprays with recommended fungicides with right dose and in proper time. Today, as never before, the decision to use chemicals to control diseases can either save a crop from certain economic loss or result in a loss of financial resources.

FungicideApplication :

The following recommend practices are be used when applying fungicides :

Cover the foliage uniformly. *Ground application*–high-volume, high-pressure applications provide ideal coverage. Make sure the sprayer is functioning properly. Check the nozzles for cleanliness and wear. Boom height, accuracy of pressure gauge, agitation, and calibration should also be checked. *Aerial application* -apply recommended amounts of fungicides in required amount of water per bigha/acre. Make sure nozzles are properly aligned and clean so that uniform application is achieved. Whenever possible, spray when the air is still or when wind velocity is low. Many new generation fungicides are available need to apply in low dose and compatible with other fungicides. However, possible tank mixture of compatible fungicides will give maximum efficacy against diseases and lowering the risk of resistance in pathogens..Some pre-mixed chemicals are available in markets which can be used for better management of diseases in vegetables. Ensure that the harvesting of produce should be done at least ten days after sprays. Mixing of stickers in fungicidal spray is more useful for some vegetable crops like cabbage cauliflower, pepper, onion etc. A list of fungicides is given below for controlling commonly occurring diseases of vegetable crops in West Bengal.

Name of the Vegetable and disease	Treatment
Beans (all types)	
Seed decay, damping-off, seed- borne stem blights	Plant certifiedpathogen-free seed. Treat seed with thiram, captan 50%WP or Carbendazim 25% +Mancozeb50% WP @ 3.0g/kg of seed
Bacterial blights (brown spot, halo light, common blight)	Utilize crop rotations of 2 to 3 years. Avoid sowing of wet beans. Field applications of copper fungicides; Applications rates vary widely with product and formulation. Application of **Bacterianashak** (2-bromo –2-Nitro -Prppane-1,3-Diol) @ 20gm/60 L of Water;
Anthracnose	Azoxystrobin 23% SC @ 0.75ml/L of water or Chlorothalonil 75% WP 2.0gm/L of water.
Carrot	
Seedling rot	Spraying of Seedling with Metalaxyl-M+ Mancozeb (4+ 64) 68% WG (Ridomil Gold) @2.5gm/L of water or Cymoxanil 8% + Mancozeb 64% WP (Moximate, Cotiriz, Curzate) @ 3.0gm/L of water or Metalaxyl-M + Chlorothalonil 440 SC @ 1.5gm/L of water – on application at germinating seedlings, if necessary 2nd application could be done at 15 days after 1st application.
Cercospora leaf spot, Alternaria leaf blight	Azoxystrobin 23% SC @ 0.75ml/L of water or Metiram 55% + Pyraclostrobin 5% WDG (Cabrio Top) @ 3.0gm/L of water or Cabri Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @2.5g/L of water – Two applications may be done at 12-15 days interval.
Crucifercrops : broccoli Brusselssprount, cabbage, Cauliflower, Chinese-cabbage, radish	
Seed rot, damping-off	*Seed-bed Application with Rose can at the 2-leaf Stage to minimise Damping-off & to bring about vigorous growth & uniformity in the size of Seedlings with Cymoxanil 8% + Mancozeb*

	64% WP (Moximate, Cotiriz) 15gm + Thiamethoxam (Coper)5gm in 2.5L of water for 8sq. ft. seed bed area. Seed treatment with Thiram or Carbendazim 25% +Mancozeb50% WP (Sprint) @ 3.0g/kg of seed; Application of Metalaxyl-M+ Mancozeb (4+ 64) 68% WG (Ridomil Gold) @2.5 gm/L of water or or Metalaxyl-M + Chlorothalonil 440 SC @ 1.5gm/L of water is the best for controlling damping off – One application as soil drenching
Alternaria Leaf spot	Azoxystrobin 23% SC @ 0.75ml/L of water or Metiram 55% + Pyraclostrobin 5% WDG (Cabrio Top, Chemtop)) @ 1.75gm/L of water or Cabrio Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @2.5g/L of water will give best result– Two applications may be done at 12-15 days interval.
Black leg	Bacterianashak (2-bromo–2-Nitro-Proppane-1,3-Diol) @ 20gm/ 60 L of Water; Copper oxychloride 50WP @ 2.5gm/L of water.
Downy mildew	Two-three applications of Dimethomorph 50% WP(Acrobat, Brunt) @ 1.0gm/L of water or Cabrio Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @2.5g/L of water at 12 days interval will give best result. Cymoxanil 8%+ Mancozeb 64% WP (Moximate, @ 2.5gm /L of water.
Rhizoctonia bottom rot	Two to three sprayings of Pyraclostrobin 20% WG (Insignia) 1.0gm/L of water or Azoxystrobin 23% SC (Amistar, Mirador) @ 0.5 to 0.75ml/L of water.
Sclerotinia stem rot	Boscalid 35% SC @ 0.75ml/L of water or Copper oxy chloride 50% WP @ 4.0gm/L of water or Mancozeb (Indifil M 45) @ 4.0gm/L of water.
White rust of radish	Two to three sprayings of Pyraclostrobin 20% WG (Insignia) 1.0gm/L of water or Azoxystrobin 23% SC (Amistar, Mirador) @ 0.5 to 0.75ml/L of water.

Cucurbits : Cucumber, Maskmelon, Watermelon, Pumpkin, Squash	
Seed rot, damping-off, seedborne diseases	*Seed-bed Application with Rose can at the 2-leaf Stage to minimise Damping-off & to bring about vigorous growth & uniformity in the size of Seedlings with Cymoxanil 8% + Mancozeb 64% WP (Moximate, Cotiriz) 15gm + Thiamethoxam (Coper)5gm in 2.5L of water for 8 sq ft seed bed area.* Seed treatment with Thiram or Carbendazim 25% +Mancozeb50% WP (Sprint) @ 3.0g/kg of seed; Application of Metalaxyl-M+Mancozeb (4+ 64) 68% WG (Ridomil Gold) @2.5 gm/L of water or or Metalaxyl-M+Chlorothalonil 440 SC @ 1.5gm/L of water is the best for controlling damping off – One application as soil drenching.
Alternaria leaf blight	Pyraclostrobin 20% WG (Insignia) 1.0gm/L of water or Azoxystrobın 23% SC (Amistar, Mirador) @ 0.5 to 0.75ml/L of water or Chlorothalonil 75% WP (e.g., Kavach, Ovate) @2.5gm/L of water : 2-3 sprays at 12 days interval Mancozeb (Indifil M 45) @ 4.0gm/L of water.
Powdery mildew	Chlorothalonil 75% WP (e.g., Kavach, Ovate) @2.5gm/L **or any Micronised Sulfer :** (Supher 80% WG (Sulfil, Thiovit): Spray @2-2.5 gms. per Ltr. of water / Sulphur 40%WG (Share) or be sprayed for controlling powdery mildew @2-2.5 gms. per Ltr. of water. Diefenoconazole 5% EC (Score) @ 0.5 to 0.75ml/L of water three sprays at 12-15 days interval or Trifloxystrobin (Flint)/Thiophenate methyl (Topsin M, Aquit) is also very effective.
Gummy stem blight/black rot of pumpkin	Pyraclostrobin 20% WG (Insignia) 1.0gm/L of water or Azoxystrobın 23% SC (Amistar, Mirador) @ 0.5 to 0.75ml/L of water or Chlorothalonil 75% WP (e.g., Kavach, Ovate) @2.5gm/L of water : 2-3 sprays at 12 days interval Mancozeb (Indifil M 45) @ 4.0gm/L of water.

Phytophthora and Pythium fruit and root rot, foliar blight	*Seed treatment with Mefenoxam (Apron) @ 5ml/kg of seed;* Foliar spray of Dimethomorph 50% WP (Acrobat, Brunt) @ 1.0gm/L of water or Cabrio Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @2.5g/L of water at 12 days interval.
Downy mildew of Cucurbits	Metiram 44% + Dimethomorph 9% WG (Acrobat Top 53% WG) @ 4.0gm/L of water is best effective; Metiram 55% + Pyraclostrobin 5% WDG (Cabrio Top) @ 3.0gm/L of water or Cabrio Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @2.5g/L of water – Two applications may be done at 12-15 days interval Cymoxanil 8% + Mancozeb 64% WP (Moximate, Cotiriz, Curzate) @ 2.0gm or Metalaxyl-M + Mancozeb (4+64) 68% WG(Ridomil Gold) @2.5gm/L of water may be applied at 12 days interval.
Solanaceous Vegetables : **Brinjal :**	
Seed rot, damping-off, and	Plant hot water–treated seed. Treat the seed with seedling diseases captan or thiram. Avoid fields with a history of Verticillium wilt. Crop rotation with small grains.
Verticillium wilt/Fusarium wilt	*Soil drenching with Thiophenate methyl (Aquit, Topsin M) @5gms per L of (100gm/acre) water may give protection Phased application of Amalgerol @ 4-5ml/L of water – 1st at 10-15 DAT & 2nd at the onset of reproductive phase.*
Phomopsis blight/fruit rot	*Carbendazim50% WP (Bavistin,Carzim etc.) @ 2.0gm/l of water* Azoxystrobin 23% SC (Amistar, Mirador) @ 0.5 to 0.75ml/L of water; Trifloxystrobin (Flint) is also effective.
Chilli :	
Damping off of chilli seeding	***Single application (soil drenching) of Metalaxyl-M + MZB (4 + 64) WG (Ridomil Gold) ranged from 0.25 to 0.3% is best effective fro controlling of damping off of chilli in nursery bed.***

Anthracnose and fruit rot and powdery mildw	Tebuconazole 25.9%EC 1.25ml/L of water; *Three applications of Tank mixed Tebuconazole 0.5ml + Azoxystrobin 0.5ml /L of water gave best result against anthracnose.* Propiconazole 5%EC (Tilt, Quash) Spray of @1ml. per Ltr. of water before Flowering and before Fruit formation is a must for chilli Myclobutanil 10% WP (Boon, Systhane)@ 4.0gm/10L of water along with **Micronised Sulfer** (Supher 80% WG (Sulfil, Thiovit) : Spray @2-2.5 gms. per Ltr. of water / Sulphur 40%WG (Share) or be sprayed for controlling powdery mildew and improving fruit yield; Penconazole 10% EC (Topas) 0.5ml/L of water may be applied for powdery mildew.
Phytophthora blight	Foliar spray of Dimethomorph 50% WP (Acrobat, Brunt) @ 1.0gm/L of water or Cabrio Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @2.5g/L of water at 12 days interval. Cymoxanil 8% + Mancozeb 64% WP (Moximate, Cotiriz, Curzate) @ 2.0gm/L of water: Tank mix of Azoxystrobin 23% SC (0.5gm) + Chlorothalonil 75% WP (1.0gm) per L of water is very effective.
Chonephora blight and fruit rot	Azoxystrobin 23% SC (Amistar, Mirador) @ 0.5 to 0.75ml/L of water is the best. Spray of (COC) Chemzole/Blitox 50/Blue Copper @30-40gms.+1gm Chemcin (Streptomycin) per 10Ltr. of water 3-4 days prior to Propiconazole spray before flowering will give very enterprising result.
Cercospora Leaf spot	In case of severe infestation: Chlorothalonil 75% WP (Kavoch,Ovate) + Propiconazole or Tebuconazole 25.9% EC (Folicure) @ 2gm + 1ml per L of water at an interval of 10 days.
Tomato and Potato :	
Early Blight	Pyraclostrobin 12.8% + Boscalid 25.2% WG (Pristine 38% WG) 1.0gm/L of water; Azoxystrobin 23% SC (Amistar, Mirador) 0.75ml/l of water is very effective for controlling this disease and enhanced the fruit yield and improve the fruit quality.

	Chlorothalonil 75% WP (e.g., Kavach, Ovate) @2.5gm/L of water : 2-3 sprays at 12 days interval Mancozeb (Indifil M 45) @ 4.0gm/L of water is also promising.
Late Blight	Avoid poorly drained fields. Avoid close proximity to pepper or cucurbit fields that sustained Phytophthora blight in the past Foliar spray of Metiram 44% + Dimethomorph 9% WG (Acrobat Top 53% WG); Metalaxyl-M + Chlorothalonil 440 SC (FOLIO GOLD) @ 1.5ml/L of water OR Cabrio Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @ 2.5gm/L of water is best effective. Total three sprays are to given using high volume Knapsack sprayer at 12 days interval. Foliar spray of Dimethomorph 50% WP (Acrobat, Brunt) @ 1.0gm/L of water or Cabrio Team 18.7% WG (Dimethomorph 12% + Pyraclostrobin 6.7%) @2.5g/L of water or at 12 days interval.
Powdery Mildew	Azoxystrobin 23% SC (Amistar, Mirador) 0.75ml/l of water
Note: *Application of Azoxystrobin23%SC, Metalaxyl-M + Chlorothalonil 440 SC, Cymoxanil 8% + Mancozeb 64% W, Metalaxyl-M+ Mancozeb (4+ 64) 68% WG must be done in alternate application of other group of fungicides or contact fungicide like mancozeb 75% WP to avoid resistance in target pathogens.*	

Conclusion :

For vegetable crop, India leads a major position in the world. But several conditions like a susceptible host plant, a pathogenic organism, a good method of distributing the organism, and the proper environment support the pathogenic organisms to exist, enter the plant, and thrive. Effective management may be taken up to combat the diseases which include use of resistant varieties; use of disease free planting materials and clean seed, either certified or grown in disease-free areas; treatment of seed with heat or chemicals; control of insects and weed hosts; monitoring of weather conditions; use of biological control agents; and proper timing and application of fungicides and ecofriendly insecticides. Effective management of vegetable and other horticultural crops diseases requires preventing disease or, if this is not feasible, slowing the spread of disease once it occurs. But much attention may be given to use modern techniques for detection and diagnosis of pathogens and resurgence of the new viruses and its strains.

PESTICIDES RESIDUE MANAGEMENT IN VEGETABLE CROPS

Saswati Pradhan, Ujjal Kumar Pati, Sambit Datta, Ashim Chowdhury, Sankhajit Roy

Preamble:

The historic green revolution made India as self sufficient in food but failed to provide adequate nutrition to most of the people.Our country accounts for the one fourth of the world's undernourished people., approx of about 250million.,15 million inW.B. Due to poor management ofAgriculture as a whole, there are lot of problems crippled all over the country including fertility deterioration, water scarcity(flood & drought), pollution & ecological imbalance& overall poor economic return for the poor farmers. It may be due to the fact that lack of interaction between technology development, transfer of technology to the end users & economic feasibility of the technology for good economic return.

Rationale :

The Agriculture sector dominates the economic scenario in our country, the occupation, of nearly 60% population in Agriculture. Just to feed them all it will be necessary to grow as much food as possible. It is evident that land is a limiting factor in food production, therefore improvement of agriculture with inputs oriented advance agricultural technologies played a dominant role for much of the today's productivity. It has been found that the increasing trend of our food grain production is directly related with increasing trend of pesticides consumption in our country, one of the key inputs, thus revealing that chemical methods of pest control served a potential role in increasing and sustaining productivity of our country.

Intensification of agriculture is a strategy to generate additional food. It is expected that year round cropping will encourage more pests(insects, disease pathogens, nematodes, weeds, rodents, birds, etc.) in the future. Because of favorable growth and multiplication conditions offered by a tropical country like India, pests assume serious proportions throughout the year.

It is, therefore, not surprising that losses due to pests are far greater in the tropics and semi-tropics than in the temperate regions of the world. It is estimated that around 36% of the attainable, agricultural output is lost due to various pests. Now the scenario is gradually been changing & everybody in these sector are looking for the adaptation of modern technology interfaced with commercial viability. At this cross roads the importance of Agri/Horti under new vision of development has been taken care of at the national & state level. High priority in the Horticulture/ Agriculture has been pointed out & fund provision has also been made, especially with the development of nature friendly high value crops with good export potential followed by processing both in national & export market.

The inputs oriented high production agri/horticulture has now been converted into the high productivity oriented Agri/horticulture followed by quality of the produces, post harvest preservation & processing. Stress agriculture (moisture stress, salinity stress etc), protracted cultivation with good quality seed/plant materials, Integrated Nutrient management, Integrated Pest management. Over & above the value addition & quality assurance of the produces & methodologies adopted are some of the important issues by means of which the high value agriculture /Hort can be sustained in world wide competition.But for fulfilling this development in Agri/Horti sound technical research& education system backup is indispensable. The researches in the general field of crop protection taking into account the section Agril chemicals, Ag. entomology, Plant pathology, Agronomy & Agril Biotechnology will be of very much relevant in this context but under new dimension.

Under this present scenario of Agri/Hort development following are some of the thrusts areas of researches in which the scientists can concentrate themselves for proper growth of the country: BroadAreas: 1. Pest management 2. Environmental quality 3. Post harvest processing, preservation, and value addition of Agri/ hort produce. 4. Quality control & assurance. Under the above broad heads following are couple of the specific areas of researches in crop protection in general. Formulation of suitable plant chemicals / Extracts as potential pest control agent. Isolation & characterization of secondary metabolites from microbial pesticides & their formulations as more effective pest control agent for targeted pests. Studies on the persistence & interaction of agrochemicals in soil, plant & water. Residue & dissipation of toxic pesticides in crops/crops parts where they are applied for combating the target pests for finding out the safe waiting period. Degradation, transformation (photo & Microbial transformation) of pesticides in ecologicalsubstrates. Metabolism of pesticides in plant & animals. Development of formulation with single/mixed pesticides.Impact of agrochemicals on fish, animals etc. Pesticides & microbial biodiversity interaction.Effect of agrochemicals on the yield & quality of medicinal, edible/aromatic oil, fruits, vegetables, spices & other high value crops & their produces/processedproducts. Quality assessment including microbiological quality of agri/hort crops & produces for export & domestic marketability

Crop Protection & Agrochemicals :

Today India has emerged as one of the largest producer of pesticides in South East Asia with an estimated market size of Rs. 4026 crores covering agriculture, horticulture, publichealth, house hold etc. Following the economic liberalization the international trade in food is increasing the food consumption pattern have triggered the demand for processed food in many countries over the last two decades and new food production, preparation and distribution techniques have developed to reflect this. Production oriented Agr/Hort development has now converted to productivity orientated development followed by quality produces. Development to that extent needs quality inputs viz; fertilizer, Agrochemicals etc. Some Consequences are Effective hygiene control, therefore, is vital to avoid the adverse human health and economic consequences of food borne disease. Everyone, including farmers and growers, manufacturers and processors, food handlers and consumers, has a responsibility to assure that food is safe and suitable for consumption. Indiscriminate use of pesticides to enhance the food production has led to resistence, and alarming situation on environmental, human and animal health front thereby, indicating clearly need for a new approach. Biorational pest management is one such approach.

Biorational Pest Management :

Since intensification of agriculture is a strategy to generate additional food, it is expected that year round cropping will encourage more pests (insects, disease pathogens, nematodes, weeds, rodents, birds, etc.) in the future.Because of favorable growth and multiplication conditions offered by a tropical country like India, pests assume serious proportions throughout the year. It is, therefore, not surprising that losses due to pests are far greater in the tropics and semi-tropics than in the temperate regions of the world. It is estimated that around 36% of the attainable, agricultural output is lost due to various pests.

Intensity of pesticides consumption :

Pest management is,a powerful strategy that can handsomely contribute to enhancement in crop productivity. Nevertheless, pest control with heavy dependence on treatment with insecticides and pesticides is fought with dangers because of their potentiality of creating harmful effect on environment and well being of man and animal. Pesticide use in India has increased from 2,936 tonnes/ annum to 98,000 tonnes/annum in 1997-98 which at the present levels is far less than the countries like China or Japan. Up to mid 70's chemical plant protection had been found to be spectacularly successful mainly due to insecticides then comes fungicides and herbicides etc. The use of pest control chemicals is still retains its importance to crop producers still to day, very difficult to deny. It has a fantastic transformation during the last 50 years from 1st generation to present generation chemicals.

What is pesticides residue : **Remaining portion / left over of original pesticide chemical and Transformation products or degradation products of pesticide which have toxic properties remaining in the substrates.**

Importance of Pesticide Residue Analysis : 1. Achievement of safety through fixation of MRL or Tolerance Limit.2. Prediction of persistence behaviour of pesticide residues through Half-Life value (T1/2 / RL50 / DT50).Recommendation of package of practices for pesticide application (time & no. of application, Safe waiting period or Pre-Harvest Interval i.e. PHI).

Residue Management : Thorough monitoring of pesticides residue occurring in various substrates is mandatory from highly specialized NABL accredited laboratory under Govt/semigovt or PVT sectors. MRL or Tolerance limit is the maximum residues remaining on a crop grown under the direct supervision of experts/scientists following Good Agricultural Practices (GAP) has to be developed after intensive research following experimental design under GAP. Then SAFETY ASSESSMENT THROUGH MRL be carried out by comparison of Theoretical Maximum Residue Contribution (TMRC) by the crop / commodity under consideration and Maximum Permissible Intake (MPI) by an individual. If TMRC <MPI, then the residue remaining in the crop is safe for consumption.

Biotechnology Tools for residue management :

The strategic integration of biotechnology tools into Indian agricultural system can revolutionizes Indian farming and usher in a new era as well in Pest control. Genetic engineering can be vital for an aggression country like India. B.It can help in minimizing crop damage through disease and pest resistant varieties. Reducing the use of chemicals enhancing stress tolerance. Biorational Pest management through biotechnology. It is also true that country like China or Japan is moving with tremendous speed. Reportedly, China plans to have 50% of its land under cultivation with transgenic in 10 years. Most important is the need for scientists, researchers, policy makers, NGOs, progressive farmers, industrialists and Government to come together on a common forum for developing this issue. With these perspectives in view, some of the thrusts areas of Agricultural Biotechnology has been outlined in which problem oriented collaborative research should be carried out. Biotechnology for production of disease and pest control agent especially microbial inoculants/bioconrol agent, mass multiplication of local viable strains and their suitable formulation up to the pilot plant Development of technology for production and extraction of phytochemicals (essential oils, alkaloidsetc.) from the specified plants followed by value addition. Identification and characterization of important sources of botanical pesticides, their isolation and suitable formulation. Molecular characterization, genetic diversity and proteomics of disease and pest tolerant locally available heirloom cultivars and other varieties of rice, tomato, brinjal etc. and identification of restriction gene function as downstream signaling compound. Generation and development of suitable methods for quality control test and monitor of all Ag. Commodities. Mode of action, metabolism and transformation of pesticides in soil. Engineering of soil microorganism for pesticide degradation for detoxification and bioremediation of Agrochemicals. Advance quality management of produces of Agriculture & Horticulture, value addition & use of immuno techniques, sophisticated instrumentations etc. for the certification of compliances at the international standards of Agricultural/ Horticultural fresh produces/processed products etc.

Conclusion :

Generation and development of suitable methods for quality control test and monitor of all Ag.Commodities for residual content in substrates. Mode of action, metabolism and transformationofpesticidesinsoil. Engineering of soil microorganism for pesticide degradation for detoxification and bioremediation of Agrochemicals. Advance quality management of produces of Agriculture & Horticulture, value addition & use of immuno techniques, sophisticated instrumentations etc. for the certification of compliances at the international standards of Agricultural/ Horticultural fresh produces/processed products etc

MANUAL FOR POTATO CLEAN SEED PRODUCTION

Dr. Subirkumar Bardhanroy

Introduction :

Good quality seed tuber is perquisite for higher potato production. Seed alone accounts for 50% of the total cost of potato cultivation. The combined use of quality seed and improved agronomic practices can therefore increase existing yield levels enormously.

Good quality seed can be produced in areas–

(i) The soils are free from *common scab, black scruf and brown rot (bacterial wilt) and nematodes.*

(ii) a period of at least 80-90 days in plains and 120days in highlands of aphid free or aphid population below thresh hold level environment is available for crop to grow.

Field practices :

Land selection : Well irrigated medium land with sandy loam soil type are best suited for seed production. Seed of one variety should be multiplied in one field. A gap of 5m or 15feet should be maintained around the seed plot. Other crop may be planted in the gap

Land preparation : Land should be leveled and prepared in early November where the seed crop is to be planted. It is imperative that field should be ploughed during summer months, and soil be kept open for some time to reduce incidence of soil borne diseases and also control perennial weeds. During first ploughing apply FYM @ 3500kg/ha. Apply granular insecticide in the field and mix with the soil.

Fertilizer application : Follow fertilizer dose 250kg N, 150kg P205 and 150kg K20.

Apply ½ N full P and 3/4th Potash as basal dose. Add another ½ N and 25% of the during the earthing up. Fertilizer should apply in furrows not by broadcasting.

Seed source :

Seed source may be tissue cultured derived 'minitubers'/ breeder seed/foundation seed free from diseases.

Seed size and seed rate :

20-30g seed tuber with multiple sprouts should be used as planting material. Optimum seed rate should be 2.0 t/ha. to get a good crop.

Planting time : Night temperature around $22^{O}C$ is the optimum period for Potato planting. Early November to Mid-November is suitable period for West Bengal.

Planting of Potato : Take out seed tuber from cold storage 10-12 days before planting. Spread the tuber in shade to get uniform germination. Separate out rotten and blunt-eye potato. Plant potato with two-three viable eyes. The distance between two rows should be kept 20 cm and plant to plant 15 cm. Adequate soil should be added to ridge to cover the seed tuber.

Irrigation : Sprinkled (Jhapta) water every 3-4 days interval from sowing to first earthing up. Apply flood irrigation in furrows at 7-8 day's interval. Take care so water do not cross half of the ridge. The frequency of watering may differ depending on soil moisture status. Potato plant should not be suffered from any moisture stress during crop growth. Watering should be stopped before 10 days of harvest.

Intercultural Operations : Weeds are a serious problem in potato crop planted without pre-sowing irrigation. Pre-sowing irrigation not only useful for uniform germination of the crop, but also helps to control the weeds to a large extent. A majority of weed species starts germinating in the field with pre-sowing irrigation and is latter killed automatically by when field is ploughed to prepare for planting. When the potato plant is 20-25 days old, the ridges and furrows are opened manually or with a plough, and the remaining half of the Nitrogen in the form of urea is applied in the furrows. The ridges are thereafter earthed up. Delay in earthing up may damage stolons, eventually resulting in yield reduction.

Monitoring and Roughing :

Regular monitoring diseases, insect and off types are essential for quality seed production. At least three inspections are needed to remove off types and diseased plants showing symptoms of mottling, mosaics and leaf-roll.

(a) the first roughing has to be done after emergence and before earthling up.
(b) the second roughing should be preformed after 40-45 days after sowing and
(c) the third roughing are to be performed just before dehaulming the crop.

While removing the diseased plants, proper precautions should be taken to avoid the possible transmission of diseases to healthy plants.

Plant protection : Application of granular systemic insecticide, Furadon 5G or Phorate 10G @ 10kg/ha at the time of planting is extremely useful to control Jassids, White flies and leaf hoppers checking the spread of victor transmitted viruses. Insecticides remain effective for 40-45 days from day of application.

Two to three sprays of Demicron/ Nuvacron/Metasystox@ 1.0 litre/ha should be applied at intervals of 10-12 day depending on appearance and population density of aphids.

For Potato late blight (LB) one prophylactic spray of Diathane M-45 @ 2kg/ ha (Mancozeb @ 0.2%) should be done on both susceptible and resistant varieties.

Dithane M-45 should be repeated at an interval of 8-12days depending upon weather conditions.

In case the spread of leaf blight is not checked by Diathane M-45, Ridomil (metalaxy) @ 4kg/ha is sprayed on the crop at an interval of 10-15days.

Dehaulming : The seed crop should be dehaulmed before the aphid population crosses the critical level (20 aphids/100 compound leaves). Haulms may be pulled by hand or cut with a sickle as close to the ground as possible. Vines should be kept on the ridges top protect potatoes from high temperature and direct sun light. Re-growth of stems should be checked in order to control vector transmitted viruses.

Harvesting : Harvesting of a crop is recommended after 10-12days of dehaulming when tuber skin is hard enough to bear handling operations. The crop may be harvested manually with a spade or a bullock driven plough/digger or tractor. At harvest time, the soil moisture in the field should be optimum to avoid damage to tubers.

The harvested potato should be kept in heaps for 5-7 days for skin curing., avoid bruising of tubers during harvesting and transporting from the field.

Grading : After curing in heaps, the seed tubers are graded to get better returns in the market. Seed potatoes are graded in four grades viz.

(a) Small size below 25g (<25mm).
(b) Medium 25-60g (25-35mm)
(c) Large 60-100g (35-50mm)
(d) Extra large above 100g (>50mm)

Seed treatment : To control surface borne diseases like common scab and black scruf (*Rhizoctonia*), the graded tubers may be cleaned with water and should be sprayed with 5% solution of boric acid. The treated tubers should be dried in the shade . Pack it in leno bags. Seed should reach cold stores timely or else the rising ambient temperature may adversely affect tubers.

Important diseases associated with seed production :

Bacterial wilt (*Ralstonia Solanacearum*) : This is a bacterial disease. The bacteria enter the plant through roots. Inside plant they multiply and eventually kill the plant. Plants that are not heavily infected can still produce tubers. These tubers contain the bacteria and carry the disease to the next season. The bacteria also survive in the soil.

Symptom : *Plants infected with bacterial wilt can easily be identified in the field. As a result of bacteria multiplying in the vascular system of the plant the flow of water from the roots to the above ground plant becomes blocked. The sprouts wilts due to a lack of moisture. This occurs despite the fact that there is no water stress visible in other plants, and the soil is actually moist.* If plants are infected in the later stages of development, when tubers are developing, the bacteria will get into the tubers and survive there. This will give following wilt symptom in the tuber.

(1) Oozing eyes
(2) Soil sticking to the eyes
(3) Vascular brown ring and Ooze come out from the vascular ring.
(4) Rotting of Tuber.

Symptomless infection :

Latent infection : Tubers infected with low number of bacteria, not showing any disease symptoms will look like absolutely healthy. But once it is planted, the plant will develop wilt and die.

Control :

1. ***Strict roughing :*** When a first symptom of disease appear a plant has to be removed with its all tubers and some soil from the plant hole. Put some ash and lime in the hole. Remove infected plant and soil and burn it.
2. ***Crop rotation :*** Through crop rotation the bacteria causing the disease will have nothing to survive on and will die due to lack of food. During rotation period no crops like tomato, tobacco, Brinjal, capsicum or other Solanaceous crops can be grown.
3. Avoid run-off from infected fields.
4. Wash tools and shoes with water or bleaching powder.

Viruses :

Seed generation caused by viruses is much less visible than bacterial wilt, but much more widespread. Once a potato plant becomes infected with a virus , there is no cure. All its tuber carry virus. Virus do not kill the plants, but make the plants sick. Over the seasons the symptoms worsen as more and more infected. This quickly results in poor yields.

Control :

Potato viruses transmitted by Aphids who feed on the sap from the potato plants. Also some other sucking insects like white flies and Thrips can transmit viruses as well as nematode and mites.

Vector control :

Sprays : Application of granular systemic insecticides, Furadon 5G or Phorate 10G 2 10kg/ha at the time of planting is extremely useful to control Jassids, whiteflies , and leafhoppers.

Two-three spray of Demicron /Nuvacron /Metasystoc @ 1.0litre/ha should be given 10-12 days intervals depending on appearance of Aphids.

Dehaulmning : The seed crop should be dehaulmed before the aphid population crosses the critical level (20 aphids/100 compound leaves)

Use of healthy seed : Regular renewal of healthy seed potatoes reduce virus effect

Roughing : Remove plants with virus symptoms.

Minimize mechanical damage : Avoid tuber damage.

Fungus :

Late Blight-disease on potatoes is caused by fungus (*Phytophthora infestans*). If late blight is controlled a whole potato crop can be lost. Late blight is rarely affecting tubers. Plants with some late blight symptoms can safely be selected as mother plants for seed.

Symptom : The symptoms of late blight are irregularly to round shaped lesion. They may be surrounded by a small band of still green or yellow tissue, that is clearly infected. Lesions are usually not delimited by the vein. Late blight can also cause lesions on the stems of the plant.

Late blight is transmitted in the form of spores which are formed on the edge of the lesions. They are transmitted over large distances by wind . From one spore landing in a potato field the whole fields can become infected quickly if the weather is right. Late blight growth is fastest under humid and cool (5-20^{O}C) conditions.

Control :

1. ***Varietal resistance :*** use tolerant potato variety like Kufri Jyoti.
2. ***Fungicides :*** (a) Contact fungicide like Mancozeb (Dithane M-45) brand name is most commonly known. It protect the leaves against the entry of the fungus into the plant. (b) sustemic fungicides like Metalaxyl protect the plant from inside.

Conclusions :

Good quality seed tuber is perquisite for higher potato production. The combined use of quality seed and improved agronomic practices can therefore increase existing yield levels enormously.

SEED INVIGORATION FOR IMPROVED FIELD PERFORMANCES WITH REFERENCE TO VEGETABLE CROPS

P. Guha and A. K. Mandal

Agricultural crop seed is considered as approaching factor of yield potential in respect of quantitative and qualitative production. Seed multiplying, seed control and seed certification programs have significant effect on genetic ancestry preservation and provision of the seeds for farmers. The literature reveals that the germination and seedling vigour are the main factors for plant establishment and making optimum plant density and plant production. Further, with rise in population a commensurate increase in productivity is imperative. Its importance has been realized with the passage of time and greater realization that efficiency is the key factor to be competitive in all the agricultural ventures. Therefore, availability of quality seed to the farmer at an affordable price and in time is considered crucial for enhancing and sustaining the agricultural productivity.

In India, the quality of seed used in agriculture is not very good from the physiological standpoint. The majority of our agricultural and horticultural crop seeds used for planting is medium and low vigour in quality. According to Banerjee (1984), less than 15% of our fields are sown in quality seed and the remaining areas are covered by seeds produced by farmers, bulk of which is without any form of quality control. He also reported that merely, by using quality seeds, yield could be increased substantially (Banerjee, 1984). There are several key factors like high temperature; humid atmosphere; infestation of storage microflora; abiotic stresses like heat, cold, drought and salinity; invading insects and rodents during seed storage; etc. which may exert drastic effects in terms of seed storage resulting in poor seed quality and affect plant growth and productivity. Seed protection in storage, although a serious problem, has not yet received due attention of the farmers. But it is essential to achieve a good quality seed as a planting material.

Harrington and Douglas (1970) and subsequently Agrawal (1976) have identified specific locations in the country which are better for seed storage than other areas and have suggested safe moisture levels for storage of seeds of various crops. In view of high humidity and high temperature conditions in eastern India and the coastal belts of the country, it is really problematic to maintain vigour and viability of stored seeds under ambient conditions. The relationship between temperature and seed longevity is that for each 10°F (5.6°C) decrease in temperature, longevity doubles (Harrington, 1972). This rule assumes that the moisture content is a constant. This is a general guideline; in reality the longevity of some vegetable species declines more rapidly than suggested by the rule, while the longevity of others declines more slowly in relation to storage temperature. The effects of temperature and relative humidity are highly interdependent in their effect on stored seed. Storage in a controlled atmosphere such as carbon dioxide, nitrogen, etc. or in a partial vacuum may prolong seed life better than storage in air, whereas storage in oxygen atmosphere tends to accelerate the loss of viability. The facilities of low humidity and temperature controlled storage are not available to the average seed producer. Even sealed storage may not be feasible; firstly, metal containers or other moisture-barrier containers are not readily available and secondly, very often the seed cannot be dried to the safe limits of moisture permissible for sealed storage. Unless the seed is properly dried, storage in sealed containers may do more harm than good.

Small and marginal farmers store seeds mostly in gunny bags or earthen-ware vessels from harvest to next sowing season which do not prevent entry of moisture resulting in significant loss of vigour and viability lead to seed deterioration. Occasional sun-drying to remove moisture is practised to retain better germinability but the same does not altogether solve the problem. An easily practicable storage technology would be welcome in such situations.

Research work on seed treatments for the maintenance of vigour and viability of several orthodox crop seeds, developed in the laboratory of the Institute of Agricultural Sciences, Calcutta University showed that mid-storage hydration-dehydration treatments were very effective in slowing down seed deterioration under ordinary storage conditions which would help the farmers to overcome the problem to a great extent and it is worthwhile to discuss the methodology of treatment and give an account of the results so far obtained.

Mid-storage wet treatments

Vegetable seeds of rabi and pre-kharif crops are more problematic than seeds of kharif so far as storability is concerned as the storage period of the former covers the hot and humid premonsoon and monsoon months. For seeds of kharif crops, storage period is characterised initially by the cool and dry winter months followed by a brief period of dry and moderately hot spell. The carry-over seeds of both types, however, lose vigour and viability because of prolonged year-round storage over all the fluctuating environmental conditions.

As the farmers usually store seeds in moisture pervasive containers, they try to maintain viability by occasional sun-drying especially towards the end of the monsoon with some positive results. Still seeds like okra, tomato, brinjal, sugarbeet, onion, water melon and several others which are relatively poor storers, loss of germinability under ambient storage is inevitable.

The mid-storage hydration-dehydration treatments, if properly done would help in maintaining vigour, viability and productivity in such situations. Some of the effective midstorage treatments are outlined below.

Soaking-drying **:** Seeds are soaked in double the volume of water or dilute solutions of different chemicals for 2-3 hours at room temperature (28 ± 1°C) with occasional stirring. After decanting off the excess water or solution, the seeds are dried back to their original weight in the sun or, if available, in a drying cabinet in a current of dehumidified air at 35 ± 1°C. The control seeds are not soaked but dried along with treated seeds. Sun-drying should be done for 2-3 consecutive days to ensure thorough drying (Mandal and Basu, 1984).

Dipping-drying **:** In this method, seeds are dipped in double the volume of water or dilute solution of chemicals for 5 minutes at room temperature. Then the seeds are taken out and kept covered for 3 hours (moist placement) for slow absorption of the surface water followed by drying back to the original weight in the sun (Mandal and Basu, 1982).

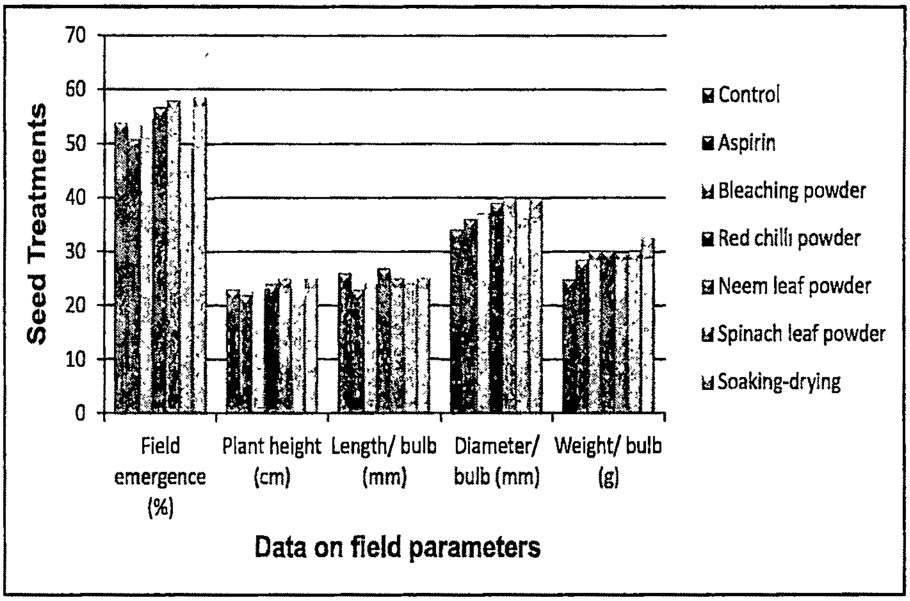
Moist sand conditioning-drying **:** This method of treatment is especially suitable for high-vigour seeds of different crops. The soaking-drying treatment is not effective in leguminous seeds and in such seeds moist sand conditioning is recommended. In this method, for each kilogramme of seed, three kilogrammes of dry sand would be required. At first the sand is thoroughly washed with clean water and then dried in the sun to make it air-dry. Water or solution of chemicals are then added to the sand in such a way that the moisture content becomes adjusted to 5-10%. To make the sand moisture content 5%, 150 ml of water or chemical solution should be added to 3 kg of sand and thoroughly mixed. The premoistened sand is then mixed with one kg of seed and kept covered for 24-48 hours. This process of seed hydration is slow and 'soaking injury' to the seed is avoided (Saha, Mandal and Basu, 1990). After conditioning, the seed is dried back to the original weight. In some leguminous seeds like soybean, it is necessary to further soak the seeds for 1 hour before drying back (moist sand conditioning-soaking-drying).

Efficacy of mid-storage wet treatments for improved field performance of some selected vegetable crop seeds

Onion is the most important edible crop grown in eastern India. The problem faced by farmers in the storage of onion seed due to loss of germinability within a short storage period resulting in poorer field performance is one of the major reasons for poor acceptability of this very important crop in eastern India.

The mid-storage treated and untreated seeds, especially the wet treatment viz., soaking-drying and a few dry treatments showed significant increase in weight per bulb and diameter per bulb over untreated control (Fig. 1).

Fig. 1 : Effect of mid-storage seed invigoration treatments on field performance and productivity of Onion (cv. Sukhsagar) seeds



Dry and wet physiological treatments were given to 5-month-old seeds. After treatment, seeds were restored in rubber stoppered glass bottles under ambient condition till sowing in the field.

Concentration : Aspirin @ 50mg/kg of seed; bleaching powder, neem leaf powder and spinach leaf powder @ 2g/kg of seed and red chilli powder @ 1g/kg of seed. Data were recorded after germination for 9 days at 23±1.5°C.

Vigour Index = G% × Seedling length

NS = Not significant

Data from Guha and Mandal (unpublished).

Okra is an annual warm season vegetable crop grown throughout the tropical and sub-tropical parts of the world for its fibrous pods which when picked young, are eaten as a vegetable.

The crop raised from mid-storage treatments, wet treatment viz., soaking-drying and a few dry treatments showed significant increase in number of fruits per plant, fresh fruit weight, seed yield per plant and 1000-seed weight over untreated control (Table 1). Among the mid-storage treatments, soaking-drying proved better results in improving fruit yield as well as seed yield and other yield attributes over untreated control.

Table 1 : Effect of mid-storage seed invigoration treatments on field performance and productivity of stored okra (cv. Pankaj) seeds

Treatments	**Plant population/ (m)2**	**Height / plant (cm)**	**No. of fruits / plant**	**Length of fruit (cm)**	**Weight/ fruit (g)**	**Fresh fruit weight/ plant (g)**	**No. of seeds/ capsule**	**Seed yield/ plant (g)**	**1000-seed weight (g)**
Control	13	55	5	8.73	8.01	43.9	44	2.18	53.5
Aspirin	18	61	8	9.15	9.39	75.3	48	4.85	61.3
Bleaching powder	19	64	8	9.80	10.10	85.1	53	4.81	63.8
Nisinda leaf powder	16	56	9	8.81	8.62	74.9	42	2.69	58.8
Neem leaf powder	18	62	9	8.76	8.82	75.6	43	3.34	62.1
Red chilli powder	17	60	9	9.35	9.82	85.0	53	5.00	62.5
Soaking-drying	20	67	10	10.68	10.74	104.2	52	4.34	63.5
L.S.D. at 0.05P	NS	NS	1.7	NS	NS	16.11	3.4	0.9	2.8

Dry and wet physiological treatments were given to 5-month-old seeds. After treatment, seeds were restored in rubber stoppered glass bottles under ambient condition till sowing in the field.

Concentration : Aspirin @ 50mg/kg of seed; bleaching powder and neem leaf powder @ 2g/kg of seed and red chilli powder @ 1g/kg of seed.

Data were recorded after germination for 7 days at 23±1.5°C.

Vigour Index = G% × Seedling length

NS = Not significant

Data from Guha *et al.* (2012).

The effects of the chemicals on productivity were more marked than their effects on germinability, and significant improvements over the water treatment were noted with sodium chloride and with sodium phosphate in both cultivars of tomato (Table 2). The yield increase was due to an increase in fruit number as well as weight of individual fruits under the effective treatments. The quality of the fruit was, however, not much influenced by the treatments and only minor differences were noted in different physico-chemical characteristics of the fruit.

Table 2 : Effect of seed treatment on productivity of tomato 'Perfection' and 'Pusa Ruby'

Treatments	'Perfection'			'Pusa Ruby'		
	Yield/plot (kg/ $10m^2$)	Number of fruits/ plant	Weight/ fruit (g)	Yield/ plot (kg/$10m^2$)	Number of fruits/plant	Weight/ fruit (g)
Control	23.9c	15.6c	44.4b	29.3c	15.9c	51.4b
Water	28.5b	18.0b	45.9ab	31.4b	16.2bc	51.8b
Sodium chloride (10-3 M)	33.7a	20.4a	48.4a	34.9a	17.2a	54.5a
Sodium phosphate (10-4 M)	31.9ab	20.0a	48.0a	33.7a	16.7ab	53.6a

Treatments were given to 5-month-old seed.
Concentration of chemicals : Sodium chloride, 10^{-3} M and Sodium phosphate, 10^{-4} M.

Within a column, values scored by the same letter, using Duncan's multiple range test, are not significantly different at P = 0.05.
Data reproduced from Mitra and Basu (1979).

Pre-storage dry physiological treatments

The wet seed treatments discussed in the foregoing pages, though highly effective in maintaining vigour, viability and yield potential, suffer from one major drawback. That is the problem of thoroughly drying the seed before re-storage. In mid-term treatments, storage of inadequately dried seed would not be beneficial and may even accelerate the deterioration process. The treatments are more suitable for the small seed lots of small and marginal farmers but hydration-dehydration treatment of large seed stocks would pose certain technological problems. Artificial drying facilities may be required for lowering the seed moisture content to the safe limits.

Dry seed treatments, which avoid use of water and do not require such drying back to safe limits for storage should be the ideal choice for large seed stocks (Sengupta *et al.*, 2005). The basic purpose of the dry treatment is to provide a protective mechanism to the seed preferably right in the beginning of storage which would alleviate deteriorative seed senescence during storage. The treatments were attempted with varying degrees of success are : (i) exposure to vapour of volatile chemicals or direct addition of volatile chemicals to the seed, and (ii) dry-dressing of seeds with inert carriers containing such chemicals like chlorine, iodine, bromine (common bleaching powder, calcium carbonate impregnated with iodine crystals, KCl, KBr, KI); pharmaceutical formulations (aspro, aspirin) and air-dried powdered plant materials (neem leaf, nisinda leaf, red chilli powder, turmeric powder, spinach leaf, etc.).

The pre-storage dry treatments like red chilli powder, bleaching powder and aspirin proved better results in increasing the number of okra fruits and fresh fruit weight per plant (Table 3).

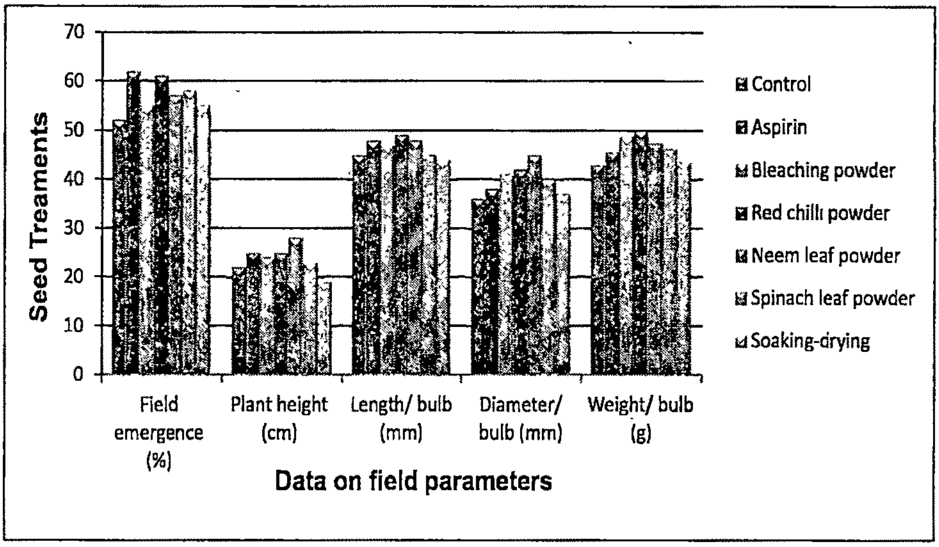
Table 3 : Effect of pre-storage seed invigoration treatments on field performance and productivity of stored okra (cv. Pankaj) seeds

Treatments	Plant population/ (m)2	Height / plant (cm)	No. of fruits / plant	Length of fruit (cm)	Weight/ fruit (g)	Fresh fruit weight/ plant (g)	No. of seeds/ capsule	Seed yield/ plant (g)	1000-seed weight (g)
Control	13	55	5	8.73	8.01	43.9	44	2.18	53.5
Aspirin	18	61	8	9.15	9.39	75.3	48	4.85	61.3
Bleaching powder	19	64	8	9.80	10.10	85.1	53	4.81	63.8
Nisinda leaf powder	16	56	9	8.81	8.62	74.9	42	2.69	58.8
Neem leaf powder	18	62	9	8.76	8.82	75.6	43	3.34	62.1
Red chilli powder	17	60	9	9.35	9.82	85.0	53	5.00	62.5
Soaking-drying	20	67	10	10.68	10.74	104.2	52	4.34	63.5
L.S.D. at 0.05P	NS	NS	1.7	NS	NS	16.11	3.4	0.9	2.8

Treatments were given to 1-month-old seed.
Data from Guha *et al.* (2012).
Other details are same as in Table 2.

In case of onion, the pre-storage treated and untreated seeds showed that all the dry treated seeds especially with red chilli powder, bleaching powder and neem leaf powder significantly improved plant height, length per bulb, diameter per bulb and weight per bulb over untreated control (Fig. 2).

Fig. 2 : Effect of pre-storage seed treatments on field performance and productivity of onion (cv. Sukhsagar)



Treatments were given to 1-month-old seed.

Data from Guha and Mandal (2012).
Other details are same as in Table : 1

Post-storage (pre-sowing) treatments

Mid-storage seed treatment is recommended for situations where maintenance of vigour and viability is difficult. The treatment should be given when the seed just starts to show a loss of germinability and usually, several months before sowing. If the farmer wants to give the treatment, the material should be with him at the particular point of time. If the seed is his own produce, there would obviously be no problem but very often he gets the seed from various other agencies just prior to sowing.

In such situations, it would be better if he treats the seed, especially medium and low vigour lots, with dilute solutions of easily available chemicals like sodium phosphate or sodium chloride. For presowing treatments, the soaking duration is more than in midstorage treatments and it is not necessary to thoroughly dry back the seed; light air-drying to facilitate sowing, or no drying at all, will serve the purpose. Mandal and Basu (1987) reported that pre-sowing treatment (soaking in water or dilute solutions of chemicals for 8h followed by light air-drying) in wheat significantly improved field performance and productivity. Similar results were also obtained by De *et al.* (2005).

The yield of water melon could also be increased by pre-sowing drying treatment employing very dilute solution of the common salt (sodium chloride) or sodium phosphate (Table 4).

Table 4 : Effect of pre-sowing treatments on germination and productivity of stored watermelon (cv. Ashahi Yamato) seed

Soaking treatment	Germination (%)	No. of fruits (m^{-2})	Yield (kg/ m^2)
Control	43^b	1.4b	5.45^c
Water	52^a	1.5b	7.65^b
Sodium phosphate (10^{-4} M)	52^a	1.9a	9.38^a
Oxalic acid (10^{-4} M)	56^a	2.1a	10.37^a

Treatments were given to 5-month-old seeds of water melon which were stored in polythene packet under ambient condition at Krishnagar, West Bengal. The soaking treatments were done in water melon for 4 hours. Duncan's multiple range test are not significantly different at P = 0.05.
Data reproduced from Basu and Mandal (1985).
Other details are same as in Table 3.

Practical significance

Improvement of seed quality by physiological treatment is a simple, easy and inexpensive approach to enhance seed performance and agricultural productivity. Invigoration techniques will either render the seed less susceptible to deteriorative senescence and ensure better storability (retention of high germinability) under ordinary uncontrolled storage conditions (ultimately giving better field performance) or, when given immediately before sowing, give better field stand and yield.

On the basis of above mentioned research, pre-storage dry treatments with aspirin @ 50mg/ kg of seed, red chilli powder @ 1 g/kg of seed and common bleaching powder @ 2 g/kg of seed may be suggested for the improvement of storability and field performance and productivity of the resultant crop. Besides, the physiological seed ageing during storage, high relative humidity coupled with prevailed high temperature also increases the incidence of storage microflora and pests which enhances pathological seed deterioration during storage (Guha and Mandal, 2011). In this situation, to check the physiological as well as pathological seed deterioration, dry physiological treatments in combination with pesticidal formulations (viz., thiram or captan or Bavistin @ 2 g/kg of seed) are recommended which would ensure a double safeguard but the hazards of such combined treatments must be made clear to the farmer.

In case of medium to low vigour seeds, mid-storage wet treatments employing soaking-drying or moist sand conditioning-drying or moist sand conditioning-soaking-drying (in case of leguminous crop) are advocated for the maintenance of germinability and improved field performance. The post-storage germinability as well as yield potential can be effectively improved with pre-sowing wet seed treatments (soaking in water or dilute solutions of chemicals for 8h followed by light air-drying) especially in case of medium and low vigour seed lots.

Conclusion :

Although appropriate techniques for improving seed performance are available, the machinery for dissemination of the knowledge is inadequate. Unless the information percolates down to the farmer, the research in the subject will only have some theoretical value and should be deemed useless from the view point of practical agriculture.

Literature cited

1. Agrawal, P.K. 1976. Identification of suitable seed storage places in India on the basis of temperature and relative humidity conditions. *Seed Res.*, **4**, 6-11.
2. Banerjee, S.K. 1984. Seed in Indian Agriculture during 1980s and beyonds. *Indian Agric.*, **28**, 115-120.
3. Basu, R.N. and Mandal, A.K. 1985. In search of low cost technologies for improving seed performance. *Proc. Symp. On Transferable Technology for Rural Development* (Ed. D.K. Dasgupta), *Associated Publishing Company*, New Delhi, pp.33-53.
4. De, B.K., Mandal, A.K. and Basu, R.N. 2005. Pre-sowing aerated and non aerated hydration treatments for improved field performance of wheat (*Triticum aestivum* L.). *Indian J. of Plant Physiol.*, **10**(2), 133-138.
5. Guha, P., Biswas, J., De, B. K. and Mandal, A. K. 2012. Post-harvest dry and wet physiological seed treatments for improved storability and field performance of okra (*Abelmoschus esculentus* L.) *Indian J. Agric. Res.*, **46**(1), 16-22.
6. Guha, P. and Mandal, A. K. 2011. Efficacy of seed invigoration treatments in combination with pesticidal formulations for the maintenance of germinability and improved field performance of stored okra *fvAbelmoschus esculentus* L.*f*w seed. *J. Botan. Soc. Bengal*, **65**(2), 165-172.

PHYTOCHEMICALS IN INTEGRATED PEST MANAGEMENT FOR VEGETABLES

Ujjal Kumar Pati, Sambit Datta, Prof. Ashim Chowdhury

Introduction :

Integrated pest management (IPM) is a system for the selection and use of pest control strategies, singly or in coordination into a management strategy that take into account the interests of and impacts on producers, society and the environment. A common character of IPM programme is a shift in the use of resources from materials to labour as applications of interventions change from calendar basis to an "as need basis". In this way a number of pest control tactics have been developed to manage various pests under different situations. However, pesticides continue to be the single most widely used pest control measure in view of their ease of application and rapidity of action. Unfortunately, conventional synthetic pesticides pose unacceptable levels of risk to human health and environment. The latest WHO data indicates that at least 3 million agricultural workers are poisoned each year by pesticides and some 20,000 deaths can be directly linked to agrochemical use. The presence of residues of these pesticides in food commodities and other components of the environment has proved toxic to humans, domestic animals, birds, fishes and other organisms. The Natural Resource Defence Council (NRDC) of USA reported that one out of 3400 children between 1 and 5 years of age could one day get cancer because of the pesticides they ate as young children. In addition to these hazardous effects the insect pest problems in many crops have aggravated following continuous application of pesticides. Many unknown species of pests have assumed serious status and have developed resistance to one or more groups of pesticides. This in turn has further increased the consumption of pesticides. To overcome the increasing problems related with the use of pesticides, efforts are being made to reduce reliance on chemical pesticides. There are some recent data which show that in European Union target of 50 per cent reduction in pesticide use by the year 2000 has been made. In USA an initiative to bring 75 per cent of US agriculture acreage under some degree of IPM by the year 2000 has been taken by USDA. One of the alternatives available to reduce the use of chemical pesticides in IPM is to depend upon plant chemicals, the "botanical pesticides"—used since ancient times to prevent their colonization by insects. These chemicals repel approaching insects, deter feeding and oviposition on the plants, disrupt behaviour and physiology of insects in various ways and even prove toxic to different developmental stages of many insects. Much before the advent of synthetic organic insecticides, neem, pyrethrum, rotenone, nicotine, ryania, sabadilla and a number of other lesser known botanical pesticides were used to protect agricultural crops from the ravages of insect and non-insect pests in different parts of world (table below).

Pesticide	*Main Source*	*Country/Region*
Neem	*Azadirachta indica* A.Juss	India
Dharek	*Melia azedarach*	L. China, India
Pyrethrum	*Chrysanthemum cinerariaefolium*	Middle and Near East, later Europe
Rotenone	*Derris elliptica* (Roxb.)	Benth. China, East Africa
	Lonchocarpus nicou (Aubl.) DC	South America
	Tephrosia vogelii Hook f.	Eastern & Southern Africa, China
	Amorpha fruticosa	China
Nicotine	*Nicotiana tabacum*	L. Europe
	N.rustica L.	Europe
	N.glauca	Argentina, Uruguay
Ryanodine	*Ryania speciosa* Vahl.	South America
Pellitorine	*Anacyclus pyrethrum* DC	Algeria
Quassin	*Quassia amara* L.	Central America, Brazil
Sabadilla	*Sabadilla officinarum*	
	Veratrum sabadilla Retz.	Venezuela, Central and South America

Phytochemicals with Insecticidal Activity :

Pyrethrum :

Pyrethrum derived from the dried flowers of *Chrysanthemum cinerariaefolium* (Treviranus) (Family, Asteraceae), has been used as an insecticide since ancient times, is a highly effective insecticide against common household insects. It is safe to mammals and is easily broken down to non-toxic metabolites. The insecticidal principals in pyrethrum, pyrethrins I and II, cinerins I and II and Jasmolins I and II are well known and pyrethrin I is the most effective. Pyrethrins act quickly via insect central nervous system, causing a knockdown effect. Addition of sesame oil or synergists like piperonyl butoxide enhances the insecticidal activity of these compounds.

Nicotine and Related Alkaloids :

Tobacco, *Nicotiana tabacum* L. (Family, Solanaceae), was used as a dust or water extract to control phytophagous insects around 300 years ago. Nicotine, the biologically active alkaloid, is now known to occur at least in 18 species; *Nicotiana rustica* being the better source as it contains 18 per cent nicotine as compared to the well known *N.tabaccum,* which contains 6 per cent nicotine only. Nicotine sulphate is effective against a wide range of pests. Its efficacy against soft bodied insects like aphids is well known, but it has also been found effective against whitefly, thrips, and bollworms in cotton; brown plant hopper and green leafhopper in rice; grubs in brinjal, potato and cauliflower, etc. Recently, cost effective methods have been developed for extraction of nicotine sulphate from tobacco waste, which could make it more acceptable for use in Indian IPM programmes.

Rotenone and Related Alkaloids :

Rotenone and related alkaloids occur in the roots of *Derris* and *Lonchocarpus* plants and in leaves and seeds of *Tephrosia* plants of Fabaceae family. Low in mammalian toxicity, rotenone is mainly active as a contact poison or a stomach poison. It mainly acts as a site I respiration inhibitor. Its rapid degradation in sunlight has limited its utility in crop protection. Synthetic rotenoids have so far proved very costly because of the complex chemical structure.

Phytochemicals Affecting Insect Behaviour and Physiology :

Neem :

Neem, *Azadirachta indica* A.Juss (Meliaceae) is indigenous to India from where it has spread to many Asian and African countries. All parts of neem tree possess anti-insect activities but seed kernel is the most active. About 413 insect species are reportedly susceptible at different concentrations of neem preparations. The growth inhibitory effects of neem derivatives result in various developmental defects, even mortality. The larvae of various lepidopterous and coleopterous pests show impaired development under the influence of neem preparations. Neem products also affect insect vigour, longevity and fecundity.

Chinaberry :

Melia azedarach L., commonly known as Dharek, Chinaberry tree, China tree, Persian lilac or "Pride of India" is a close relative of neem tree. The work on active principles has revealed the presence of azadirachtin related limonoids in *M. azedarach.* The compounds isolated included melianone, melianol, meliantriol, toosendanin, meliacarpins, etc.

Karanja :

Pongamia pinnata (Linnaeus) (Syn. *P.glabra* Vent.), variously known as karanja, puna oil tree, Indian beech or Pongram, is indigenous plant of India. The active component in this plant is karanjin, a furaflavone.

Conclusions :

Botanical pesticides in IPM offer several advantages over the synthetic pesticides. As plants have developed these chemicals in response to the combined selection pressure of different pests, many of these pesticides are effective against diseases, nematodes and other organisms in addition to phytophagous insects. The naturally occurring phytochemicals exert a wide range of behavioural and physiological effects on insects and, therefore, it is difficult for insects to develop resistance easily against these pesticides. The limited number of studies conducted so far indicates that neem and some other botanicals are comparatively safe to natural enemies and higher organisms. The available evidence indicates that botanical pesticides are biodegradable in contrast to persistent synthetic insecticides. Many of these products can be developed from indigenous plant sources which can save foreign exchange of the countries. Moreover, village cooperatives can take up the formulation of locally available plants which will ease the cost burden of farmers in the region.

Quality control in botanical pesticides is serious problem. There is wide variation in the quality and quantity of extractives obtained from a plant due to variation in ecotypes, environmental factors, etc. Such variations influence the performance of formulated products. There is an urgent need to develop and prescribe suitable standards for registration of these products. The new pharmacological and biochemical tools developed for evaluating the hazards of synthetic chemicals must be utilized for testing the promising materials from natural sources. These efforts will certainly enable us to identify selective, diverse, renewable, cheap and environmentally acceptable plant products from the repository of nature for use in IPM programmes.

References :

1. Benner, J.P. (1996) Pesticides from nature. Part I. Crop protection agents from higher plants—An overview. In L.G.Copping (ed.), *Crop Protection Agents from Nature: Natural Products and Analogues,* The Royal Society of Chemistry, Cambridge, UK, pp. 217–229.
2. Berger, A. (1994) *Using Natural Pesticides: Current and Future Perspectives.* A report for the plant protection improvement programme in Botswana, Zambia and Tanzania. Swedish University of Agricultural Sciences, Uppsala, Sweden, 37pp.
3. Kogan, M. (1998) Integrated pest management: Historical perspectives and contemporary developments. *Ann. Rev. Entomol.,* 43, 243–270.
4. Koul, O; Dhaliwal, G.S., (2005) *Advances in Biopesticide Research,* vol-1: *Phytochemical Biopesticides,* Harwood Academic Publishers, U.K..
5. NRDC (1989) *Intolerable Risks: Pesticides in our Children's Food.* Natural Resources Defense Council, National Resources Institute, Washington DC.

POTATO CULTIVATION THROUGH T.P.S (TRUE POTATO SEED) - A REVOLUTION

Dr. Pinaki Acharyya, Uttam Saha

Introduction :

The potato is already an integral part of the global food system. It is the world's number one non-grain food commodity, with production reaching a record 325 million tones in 2007 (FAO,1995). Potato consumption is expanding strongly in developing countries, which now account for more than half of the global harvest and where the potato's ease of cultivation and high energy content have made it a valuable cash crop for millions of farmers.

At the same time, the potato – unlike major cereals – is not a globally traded commodity. Only a fraction of total production enters foreign trade, and potato prices are determined usually by local production costs and not by the vagaries of international markets. It is, therefore, a highly recommended food security crop that can help low-income farmers and vulnerable consumers ride out extreme events in world food supply and demand.

In Peru, for example, the government has acted to reduce costly wheat imports by encouraging people to eat bread that includes potato flour. In China, the world's biggest potato producer, agriculture experts have proposed that potatoes become the major food crop on much of the country's arable land.

Potatoes are rich in carbohydrates, making them a good source of energy. They have the highest protein content (around 2.1 percent on a fresh weight basis) in the family of root and tuber crops, and protein of a fairly high quality, with an amino-acid pattern that is well matched to human requirements. They are also very rich in vitamin C - a single medium-sized potato contains about half the recommended daily intake - and contain a fifth of the recommended daily value of potassium.

Global Scenario - trend :

World potato production has increased at an annual average rate of 4.5 percent over the last 10 years, and exceeded the growth in production of many other major food commodities in developing countries, particularly in Asia. While consumption of potato has declined in Europe, it has increased in the developing world, from less than 10 kg (22 lb) per capita in 1961-63 to almost 22 kg (48.5 lb) in 2003 (Inter). Consumption of potato in developing countries is still less than a quarter of that in Europe, but all evidence suggests it will increase strongly in the land. India has plans to double its potato production (FAO, 2008).

The potato is produced in 130 nations (more nations than any other crop, except corn). Potatoes can be grown at almost any elevation and in most climates.

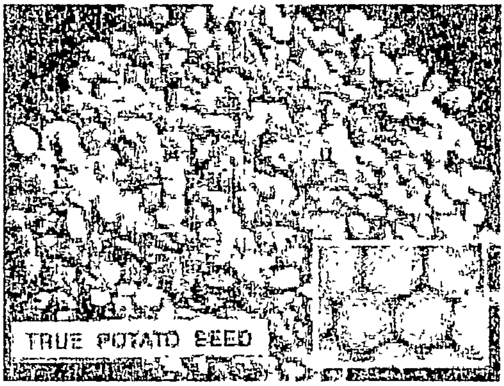
Although it originated in the cold, dry Lake Titicaca region of Peru and Bolivia (elevation 12,500 feet) between 7,000 to 10,000 years ago, the potato thrives in wet, warm costal areas. The potato plant requires very little water, matures in as little time as 50 days, and can produce four times more food on the same amount of land, than can wheat or rice. One acre of potatoes can feed 10 people for a year. After being harvested from the ground, the potato can be stored for six months or more under cool, dry, well-ventilated conditions—thus providing food all year long.

The potato has been regarded as poisonous, tasteless, boring, fattening, hard to digest, and as an aphrodisiac; it has been considered cattle- and pig-food, reserved only for times of famine and for the poor. In truth, science and history have consistently judged a potato-based diet correctly: a diet ideal for supporting human health and productivity.

Because of the ease and efficiency of production, and the superior nutritional qualities, the humble potato is humankind's best hope for, resolving the current worldwide epidemic of obesity, diabetes, heart disease, and cancer, and eventually, thriving in the near future. The potato plant produces more nutritious food, quicker, on less land, and in harsher climates than any other major crop. For these reasons potatoes are the world's fourth most important food source after rice, wheat, and corn. With climate changes brought on by global warming, the potato will soon become the world's most important crop. Historically, this common vegetable has gained a well-deserved reputation for protecting population from starvation and improving the lives of ordinary people.

WHAT IS TPS?

A Revolution In Potato Cultivation....



True Potato Seeds or T.P.S are tiny botanical seed of potato substitutes a bulky quantity of Potato seed tuber and high yielding homogenous population (Martinetti, 1987).

Non-availability of quality seed tubers, high seed cost, virus infiltration in seed tubers causing degeneration of seed stocks and problem of long distance transportation of seed from seed-producing areas have led to the development of true potato seed (TPS) technology of crop production. This technology envisages the use of botanical seed or TPS for crop production. It has gained significance because unlike seed tubers, TPS can be produced in all parts of the country providing extra light for 4-5 hours depending upon climatic condition. It can be easily stored over long periods of time. Disease transmission by TPS is negligible and it provides cheap planting material. About 100-120 g TPS is enough to raise a seedling crop for one hectare or if the commercial crop is to be produced using seedling tubers, the produce of 40-45 g TPS is enough to plant one hectare crop next year. They also provide better disease resistance because of high heterogeneity in the population.

Why T.P.S.?

- 100 grams is sufficient to cover one hectare instead of planting 2-2.5 tons of Potato seed tuber.
- Being hybrid it is capable of giving more production.
- Absolutely disease free seed material.
- No cold storage facility is required for storing T.P.S.
- Practically no cost is involved for transporting T.P.S. unlike seed tuber.
- Comparatively more resistance to pests and diseases.
- Net profit is more as cost of cultivation is less and per hectare production is much more.
- The seed tubers being utilized could be otherwise used for consumption.

Cost of production of potato using TPS is approximately 55%less in comparison to cost of production of potato using seed tuber. At the same time production may be obtained up to the level of 35 MT per hectare.

Steps for Production of Hybrid TPS :

- Maintenance & multiplication of parental lines through tissue culture
- Production of virus free pre-basic seed of parental lines from tissue cultured plantlets under net house condition.
- Multiplication of basic seed of parental line in open field through seed-plot technique for subsequent use in crossing block
- Artificial illumination for extra 4-5 hours in crossing block with 35-40 lux intensity
- Collection of pollen grains for pollination
- Artificial pollination of female flowers
- Higher pollination efficiency is achieved by dipping the receptive stigma of the female flower into the pollen grains collected in shallow vial
- Formation of berry after 6-7 days of pollination. Berries ready for harvest after 45-50 days of pollination

- Softening of berries at room temperature for 10-12 days
- Extraction of seed with a manually operated screw type juice extractor
- Fermentation & separation of seeds from pulp washing of seeds by density gradient
- Extraction of seed
- Seed dried in shed till moisture content reaches below 10%, then dried in a seed dryer machine to bring down the moisture level at 6%.
- Stored in air tight container with desiccant
- After breaking dormancy TPS is packed in moisture proof aluminium coated foil for distribution to the cultivators.

PACKAGE OF PRACTICES FOR POTATO PRODUCTION FROM TPS :

Raising Seedling :

Seeds are sown at 0.5 cm depth in raised nursery beds (6 inches or 15 cm) prepared to good tilth with finely powdered dry cow dung in rows at 10 cm apart & provide shed. Water with fine rose can. Apply foliar spray 0.01% Urea solution from 15th day after sowing on alternate days till the seedlings are ready for transplanting (25 to 28 days) with 3 to 4 leaf stage. Care should be taken against termite and damping-off.

Seedling from TPS

Cultivation in the main field :

Prepare main field to a good tilth. After leveling apply fertilizers @ 75:100:150 kg. NPK per hectare. Make ridges (6 inches or 15 cm. height) furrows at 50 to 60 cm. apart in east - west direction. Irrigate the furrows to 3 inches or 7.5 cm height. Transplant the seedlings on the next day on the northern side of ridges at half the height at 15cm apart. On 35th day apply 75 kg. Nitrogen per hectare after weeding and earthing up is to be done in such a way that the plants come up on top of the earth. Provide irrigation as and when required.

Seedling transplanted

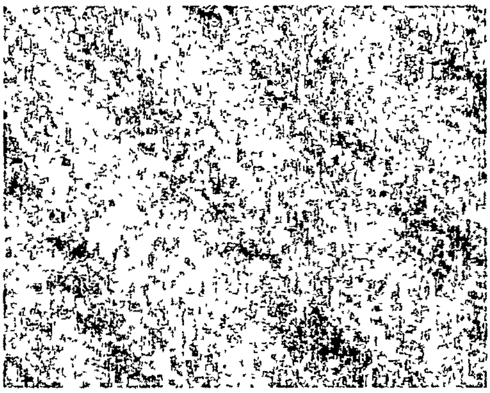
What is tuber let ?

Small tubers up to 20 grams size are used as seed tubers (Patel *et al.*, 2002). Seed tuber requirement could be brought down to one-third by using tuberlets.

Package of practices of production to Tuber let using T.P.S. :

At present there are two methods in practice for producing seedling tubers in bed – Single Row Method and Double Row Method

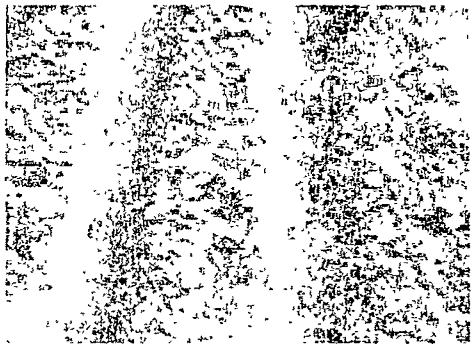
Single Row Method :


Single row method

Prepare beds of 6 inches or 15 cm. height, 1 mt. width and according to convenient length at 0.75 cm apart. Bring to good tilth by mixing with finely powdered well-rotten dried cow dung and apply Urea, S.P and M.O.P. @ 20 gms, 60 gms & 25 gms./ Sq.mt. respectively as basal dose. Sow 2-3 seeds per hole at 0.5 cm. depth with 20 cm.×5 cm. spacing. Provide shade to avoid scorching sun and irrigate the beds with fine rose can as per necessity. Earth up with the mixture of finely prepared soil and cow dung along with Urea @ 5 g./sq. mt. at 30th , 45th and 60th day of sowing. Cut the haulms on 85th day. During the Whole production period, need based spraying with P.P.C. should be undertaken. Treat the Tuber lets with 3% Boric-acid and store in cold storage for next year after proper drying in shade. About 50 g TPS and 375 sq.m.nursery bed area are required for producing enough seedling tubers for planting one hectare area the next year.(Extension Bulletin No. 30(E)-Manual for True Potato Seeds(TPS) Production AND Utilization-CPRI, ICAR,SHIMLA, H.P., INDIA)

Double Row Method :

Preparation of field and other operation are same as single row method except sowing of seeds. In Double Row method seeds are sown 4 cm. apart in a line and


Double row method 30 DAT

Double row method 60 DAT

row to row distance is maintained at 10 cm. In between two double row distance is 30 cm. Top dressing with 5 gm. Urea per Sq.mt. on 30th , 45th and 60th day followed by earthing up as practiced in normal crop is done so that two lines can be covered by a single furrow.

Harvesting and Yield :

The crop requires about 100-110 days after transplanting to come into harvestable maturity. Yield of Table potato from transplanted seedling is around 30mt/ha and from seedling tuber (tuber let) is 35 MT in the subsequent year while from traditional tuber it is only 20 MT/ha. (Patel *et al.*, 2002)

References :

1. FAO (2008). International year of the Potato-2008, http://www.potato2008.org / en/aboutiyp/
2. FAO (1995). Statistical summary of Agricultural production. *Bull. Statistics.* **5** (1): 14-17
3. Martinetti, L. (1987) Potato production from true Potato Seed in Italy. *Production of new varieties: Technological Advances.* Cambridge University Press. Cambridge. P. 266-268
4. Patel, B.T.; Barad, A.V.; Chaudhuri, S.M.M.; Patel, C.K. and Patel,R.N. (2002) Standardization of Spacing for seed tuber let production from TPS under nursery bed in Gujrat. *J. Indian Potato Assoc.* **29** (3/4): 143-146
5. Extension Bulletin No. 30(E)(1996)-Manual for True Potato Seeds(TPS) Production AND Utilization-CPRI, ICAR,SHIMLA, H.P., INDIA)

NANOTECHNOLOGY – OUR MANTRA OF PRESENT AND FUTURE IN AGRICULTURE AND FOOD

Savitri Chakraborty & Ashim Chowdhury

Introduction :

We are well accustomed to the proverb small is beautiful! Nano comes from the Greek word for dwarf. Nanoparticles are characterized as those with the particle size of hundred nanometer , thus this unique phenomenon enables noble application and benefits. Since this is a very new field and the potential of resource is wide, a new range of nanoscale techniques, materials and products are currently being developed though they are still at grass root level of research across all agri-food business including food packaging, food manufacturing and retailing.

Nanotechnology has offered a range of benefits across the agri-food system like increasing productivity, environmental benefits include reduced chemical use thus decreasing residue and pollution and adaptation to changing ecological condition thus more nutritious and safe food. Nanotechnology is being considered as a potential candidate to help in meeting the needs of growing population, combating hunger and also meeting the challenges of climate change and other ecological degradation (Hinsliff 2009).

The global population presently is nearly 6 billion. Those living in developing countries face the challenges of food shortages while in developed countries there is food surplus, the research are focused on developing drought and pest resistant crop and maximizing yield. Nanoscale technologies are currently being used to increase agricultural food production, distribution and consumption. Nano packaging innovations can facilitate the long distance transportation; improve shelf life and nutritional benefits. Nanotechnology will end up making break through in ways that we cannot yet anticipate. It is powerful and we have to ensure that we harness its power towards useful ends.

Nanotechnology in the food market :

Nanotechnology is the new industrial revolution and both developing and developed countries are investing in this to secure a market share. USA has invested 3.7 million USD since last four years followed by Japan 750 million and European Union 1.2 billion. In Asia China, India, South Korea and Thailand are also investing in this technology focusing on its use on Agriculture and food industry.

Increase in population brings the challenge of producing healthy and safe food. The change in weather pattern is further detrimental. Nanotechnology has the potential to revolutionize the agriculture and food industry with new tools for molecular treatment of disease, early detection of disease and enhancing the scope of plants ability to absorb nutrients. Smart sensors and smart delivery system will help in combating virus and other pathogen. Nanostructure catalyst will increase efficiency of pesticides and herbicides allowing lower doses to be used. Thus this will protect the environment by reducing pollution.

Another agricultural methodology widely used today in USA, Europe and Japan is called CEA (Controlled Environment Agriculture). Plants are grown in a controlled environment and thus provide an excellent platform for introduction of nanotechnology in agriculture. Nanotechnological devices could improve ability to determine best time for harvest of the crop, vitality and detection of pest and pathogen infestation.

Precision farming aims at maximizing crop yields while minimizing use of fertilizers, pesticides and herbicides. Thus it concentrates on targeted delivery. It uses computers; Global satellite positioning systems and remote sensing devices thus determines whether the crops are growing at maximum efficiency. This can be tuned to lower production costs and thus increase the farmer's profit. It can also help to reduce agricultural waste and thus keep environmental pollution to minimum.

One of the major roles of nanotechnology device will be increased use of autonomous sensors linked to GPS system for monitoring. These nanosensors are distributed throughout the field where they monitor soil condition and crop growth. Wireless sensors are being used in parts of USA and Australia .In California vineyards wi fi systems have been installed with the help of IT Company. Though the initial cost of installing this is very high it is justified by the high price of wine due to harvesting of grapes at the optimum ripening (Virtual vineyard, Gregory J Millman, Accenture). Nanosensors are also being used by Honeywell to monitor grocery stores in Minnesota. It helps the shopkeepers to detect food which have passed their expiry date and also to issue a new purchase order (Quentin Hardy, sensing opportunity, Forbes magazine 2003).

Smart Delivery systems :

Nanoscale devices with novel property could be used to identify plant pest and disease infestation even before they become visible to the farmer. These devices will alert the farmer early about the problem and can also be used to deliver chemicals in a controlled and targeted manner.

Encapsulation and controlled release method have bought a revolution to use of pesticides and herbicides. Formulations with nanoparticles (100-250nm) size dissolve readily in water and thus increasing their activity. Syngenta is using nanoemulsion in its pesticide product Karate Zeon is a quick release micro encapsulated product containing Lambda –cyhalothrin which breaks open on contact with leaves (http://www.syngenta crop protection –us.com/prod/insecticide/karate/).Research is also going on to make plant use water, pesticide and fertilizer more efficiently and to reduce pollution thus making it more environmentally friendly.

One of the first nano industrial applications is the development of nano pesticides. These are pesticides that contain nanoscale chemical toxins. These formulations offer a range of novel properties such as increased toxicity, stability and higher dissolving power in water compared to large-scale molecules of the same toxin. Furthermore nano encapsulation of pesticidal toxins offers possibility of controlled and targeted release of pesticides example in alkaline environment of certain insect's digestive system and under specific moisture and heat levels (ETC group 2004, Kuzma and Verhage, 2006; FOE, 2008). Due to the targeted delivery of nano pesticides it can result in the reduction in the volume of chemical pesticide applied in specific situations and thus reducing input cost and environmental pollution (Kuzma & verhage 2006).

On the other hand nanoscale pesticide with the increased dissolvability unleashes a new range of possible health and environmental hazards. Presently there is an absence of labeling for nanoscale chemicals (Bowman and Hodge 2007). There is still an ample scope of research in these areas and new strategies and policies needs to be formulated.

In the area of analysis and detection introduction of bio- sensors will help in detection of surface and airborne pathogens. The bio sensors are composed of a biological component linked to a tiny transducer. They detect changes in cells and molecules even in low concentrations. With the increase in concentration of bacteria in a particular food strong signal will be produced indicating that the food is safe for consumption.

Chakraborty et al (2007) developed quantum dot conjugates CTB- Cholera toxin subunit B for labeling mammalian cells. The conjugates were initialized by all tested cell lines into small vesicles dispersed through out the cytoplasm. Although a large proportion of CTB conjugates eventually also accumulate in perinuclear endosomes, this accumulation requires several days. CTB conjugates are a practical alternative to ployarginine conjugates for the general labeling of the mammalian cells.

Fluorescent labeling of cells helps us to track movement, cell division & cell interaction invitro and invivo. Bruchez et al (1998) and chan et al(1998) originally reported cell labeling by using quantam dot conjugates. Both the groups stated that the excellent fluorescent properties of quantam dots (brightness, choice of many emission maxima, chemical stability and photo stability) makes it a very good candidate for cell labeling especially cell tracking over a long period of time. Langerholm et al (2004) developed the use of polyarginine- conjugated quantam dots as a general cellular label. These quantam dots are absorbed by the cell very rapidly.

Other developments in Agricultural sector due to nanotechnology :

Increase in population brings the challenge of producing healthy and safe food. The change in weather pattern is further detrimental. Nanotechnology has the potential to revolutionize the Agriculture and food industry with new tools for molecular treatment of disease, early detection of disease and enhancing the scope of plants ability to absorb nutrients. Smart sensors and smart delivery system will help in combating virus and other pathogen. Nanostructure catalyst will increase efficiency of pesticides and herbicides allowing lower doses to be used. Thus this will protect the environment by reducing pollution.

Another Agricultural methodology widely used today in USA, Europe and Japanese called CEA (Controlled Environment Agriculture). Plants are grown in a controlled environment and thus provide an excellent platform for introduction of nanotechnology in agriculture. Nanotechnological devices could improve ability to determine best time for harvest of the crop, vitality and detection of pest and pathogen infestation.

Nanotechnology can be used to clean groundwater. Agronide an US company is using2nm dia Aluminium oxide nanofibres as water purifier. These fibers when used to make filters can remove virus, bacteria and protozoa cysts from water (http://nanotech web.org/articles/news/3/4/7). Research at center for Biological and Environmental Nanotechnology has shown that nanoscale iron oxidized particle is extremely effective at binding and removing arsenic from groundwater.

Sukul et al (2009) have reported that potentized drugs significantly increased plant growth, chlorophyll protein and water content in the leaves as compared to the control. ccc30(nano) was found to be more effective than ccc30. Potentized drugs are thought to initiate their action on the integral membrane proteins of the leaves and modulate cell physiology towards growth.

Research on nano particles & insect control should be geared towards introduction of faster and eco friendly pesticides in future (Bhattacharyya et al 2007). Leading chemical companies should focus on formulation of nanoscale pesticides for delivery into target host tissues through nano encapsulation. Nanotechnology benefits are enormous including increasing agricultural productivity , slow and efficient release of water & fertilizer, nanocapsules for herbicide delivery and nanosensors for pest detection. (Scrinis & Lyons, 2007, Scott 2007, Joseph and Morrison 2006, Liu & Du 2004)

Nano Engineering of functional foods :

In food manufacturing sector nanotechnology can contribute a lot. Nano engineering can lead to development of cheap and processed food. It is used to modify food flavor and texture, speed of processing, shelf life, nutritional profile and heat tolerance. Nanotechnology enables introduction of new traits into food. Food ingredients were developed which were able to produce the creamy taste and structure of full fat products as this will help in enhancing the flavor of low-fat ice cream and spreads (Choudhury et al. 2008).

Encapsulation of cucurmin the chemical found in turmeric and possessing antitumor and anticarcinogenic properties has increased the bioavailability of this compound (Wang et al., 2007). To protect micronutrient from the degradation during manufacturing and storage and nano cochleate nutrient delivery system has been developed (Chowdhury et al. 2008). It also holds the promise of enabling to change the nutritional profile of food in response to individual allergy, dietary needs or preferences (F OEE, 2008).

Pustzan & Bardocz(2006) observed while studying the health risk of nanoscale food components that nanoparticles version of food additives titanium oxide and silica dioxide and already used in food have been approved as GRAS (generally recognized as safe) by US Food and drug administration but there is already sufficient scientific evidence indicating that these nanoparticles are cytotoxic and adding them to food has been done without proper testing.

Food packaging and supply chain monitoring :

The use of nano materials for food packaging poses health and environmental hazards, as these materials may migrate from packaging into food and thus increase the possibility of nano material ingestion (Chowdhury et al. 2008). (EDC, 2004) Furthermore packaging containing nano sensors will change color once the food begins to spoil or if there is microbial contamination. Nanoscale barcodes and monitoring device are also being developed and commercialized. These include nanoscale radio frequency, identification tag (RFID) that will be able to track containers of individual food items.

On one hand nano pesticide will allow more targeted and reduced use of chemical input on farms, it may also facilitate overall expansion of large-scale and resource intensive system of farming, food manufacturing and distribution and ecological problems associated with them.

Developing smart packaging to optimize shelf life has been the goal of many companies. These packaging system alert customers if the food is contaminated or if it is due expiry date, it responds to environmental conditions (eg temp and moisture changes). It also alerts customers if the food is spoiling. Nanotechnology can also provide solutions for improving mechanical and heat properties, developing antimicrobial and antifungal surfaces. Today consumers demand much more from packaging in terms of protecting the quality, freshness and safety of food. Kraft food along with Rutgers University in US is developing an "electronic tongue" for inclusion in packaging. This contains an array of nanosensors which detect gases released by food as it spoils thus alerts us if the food is not fresh.

Bayer polymers developed Durethon KU2-2601 packaging film which is lighter, stronger and more heat resistant. This prevents the contents from drying out. The new film is enriched with numerous number of silicates Nano particle. These reduces the entrance of oxygen and other gases and exit of moisture thus preventing food from spoiling (Nanoparticles make Durethane films airtight and glossy, Bayer polymers).

Nanotechnology can offer improvements in sensitivity of detecting contaminated food. Agronmicron has developed Nano Bioluminescence detection spray which contains luminescent protein which binds to surface of microbes such as Salmonella and E.coli . It emits a visible glow thus allowing early detection.

Nanotechnology is used in monitoring and tagging of food items. RFID (Radio frequency Identification) is used in food monitoring in shops for improving supply chain efficiency. Aim to produce nanomaterials with functional properties along with nanosensors and nanofludic technology to be applied in food science. It also aims in producing intelligent packaging materials making it possible to monitor the condition of the products during transportation.

Food Processing :

Nanotechnology can also help in development of functional and interactive foods which will deliver nutrients depending on body's need. Nanocapsules are being developed which can be incorporated into food to deliver nutrients. One of the leading bakeries developed bread containing tuna fish oil (a source of omega 3 fatty acid) which breaks open only when it reaches the stomach.

A number of companies are researching additives which are absorbed by body and can also increase shelf life. Biodetecting science International have developed Nanocochleates which are 50nm nanoparticles and can be used to deliver vitamins, Lycopene and omega3 fatty acid more efficiently without effecting colour and taste of food.

Other uses :

The prospect of nanostructured materials in use of devices for pollution sensing, treatment and remediation are being considered. Nanoparticles for pollution prevention through different synthesis are also being explored (Duebendorf, 2008)

Top Ten Nanotechnology applications are
Energy storage and production
Agricultural productivity enhancement
Water treatment and remediation
Disease diagnosis and screening
Drug delivery systems
Food processing and storage
Air pollution and remediation
Construction
Health monitoring
Vector & pest detection and control.

(April 7th 2005, Global experts rank top ten Nanotechnology applications to aid poor. US-based public library of science journal PLOS medicine.)

Conclusion :

Nano food innovations are still at very initial stage of research. We still lack the nano specific regulations. It is yet to be seen if organics and competing corporate interest will retard or redirect the development of nano food application. Until recently there were no national or international regulations to nano food particles, nor are there any specific internationally agreed protocols for assessing the toxicity or environmental impact of nanoparticles (Food and Agricultural standards 2006, Bowman 2008).

In early 2009 two significant moves changed the scenario. The Canadian government introduced the world first's nano specific regulations and called for mandated reporting on the use of nano materials .It was also proposed in European Parliament that food produced via nanotechnology should undergo risk assessment prior to approval, it also called for clear labeling of nano foods (European Parliament 2009). Like it has occurred with GM crops due to tighter regulation and consumer resistance in the north (developed countries) nano food could end up in the underdeveloped countries since research is still at very initial stage it could raise the issue of concern among consumers similar to GM foods (kearnes et al, 2006).

Many scientists, government agency are joining civil society group calling for effective risk assessment procedures related to nano food products. Acceptance of nanotechnology will depend on large-scale research. There is still scope of research, formulating new policies the first and foremost criteria understanding the food processing at nanoscale. It is still at a very grass root level of research. Currently food products using nanotechnology is still very small. It does promise big and benefits for food safety, quality and shelf life. There is an opinion among scientists and researchers that nano materials are fundamentally different substances that can cause risk to human health and environment and thus need monitoring. Nanotechnology has the potential to improve food, making them healthier, tastier and more nutritious. Measures can be used to make packaging that keep the product inside pressure for longer time. This could also provide consumers with information on the state of the food inside.

Advances in for that nanotechnology offers challenges to government and industry, the food processing industry must ensure consumer confidence and acceptance of nano food. FDA and other regularly trade bodies should offer guidance and investment to the criteria to be followed in evaluating the safety of food, food packaging and supplemental and use of nano materials with novel properties.

Nano foods are not the same thing as conventional food. It is very difficult to come to the general conclusion as to whether nanotechnology is good or bad for us. We don't have sufficient scientific exploration of whether naturally occurring nanosystems are beneficial to us or not however nanotechnology food packaging was assessed as less problematic. Mandatory testing of nano modified food is needed before they are allowed into the market. Standardized test procedure are needed to study the impact of nanoparticles in living cells as this will evaluate the potential hazards relating to human exposure to natural nanoparticles.

The potential of nanotechnology has been identified by many countries and many countries are investing significant amounts. The USDA has developed short term and long term plans to address challenges faced in the agricultural sector. More money has been allocated towards research and development for increasing and optimizing food colour, flavour and consistency.

In developing countries like Iran, they have developed their own nanotechnology program with a focus on agriculture. They have 35 laboratories with a focus on agricultural research. In India 22.6 million USD in 2006 budget has been allocated to Punjab Agricultural University in recognition of their contribution to green Revolution.

However there is concern over using nanoparticles in food as has arisen in case of GM crops. A recent report from Institute of food science and technology in UK has stated that more safety data are needed before nanoparticles are introduced in food, since in current legislation it is not required to incorporate use of nanoparticles in food labels so consumers are more likely to be unaware of its use in food items. Many questions still remain unanswered regarding the extent to which the concerns raised by public and civil society groups will shape future trajectories of nano agri food industries. A number of models for public engagement have been proposed to give a platform for expressing concern associated with the development of nanotechnologies. Many of these models have been criticized both for limited extent to which diverse interest groups have been included in deliberative dialogue and also for gaps in process of deliberation and actual formation of policy and regulation related to nanotechnologies (Lyons and Whelan, forthcoming, 2009). Limited public participation may cause consumers lack of trust as has happened in case of GM food resulting in global opposition to GM crops and hence boycotting GM crops. (Cocklin et al, 2008)

The future of nanofood applications is uncertain so the organic agri food sector has excluded nanotechnologies. In 2008, the UK soil Association -the world's oldest organic certifier has prohibited the listing of products derived from nanotechnology due to unknown ecological and health risk associated with exposure to nano particles. Organic certifiers around the world like the Biological farmers of Australia are also following this lead and it is possible that more general food standards will exclude nano products and processes (Lyons, 2008).

Public and industry are concerned about controlling nanotechnology, managing the risks and considering potential gaps in regulation. Workers in industry and students in academic labs are the ones exposed to nano particles right now especially in developing countries where infra structure and training for health and environmental safety are lacking. Regulatory guidance is particularly important for small business which does not have the resource to devote to environmental health and safety. With growing number of nano based products out on the market, the federal oversight process will increasingly have trouble keeping up with the pace of product development and market entry as it will take several years to fund and conduct research on the health and environmental risks and even longer to amend or formulate regulations (The nanotechnology – Biology Interface: Exploiting models for oversight. Sept 15th 2005, Workshop Report).

The health and environmental impacts of nanoparticles and nonmaterial's should be assessed. Environmental application of nanotechnology include improved monitoring& detection capabilities, ultra green manufacturing and chemical processing, waste minimization, reduced energy usage, clean energy sources, remediation and treatment technologies and sustainability applications. Implications research for nano materials include studies on toxicity and its mechanism, effect of manufacturing on ecosystem., transportation & fate of nano materials bio accumulation, transformation ,availability & dose response assessment.

Nanomaterials can be used to penetrate & remediate subsurface areas but this could also lead to damage to ecosystem. EPA governs nanotechnology so as to protect the environment. Right now the promise of nanotechnology is still much undetermined so developers need to be very careful about what the promise nanotechnology can do. This can lead to adverse public reaction.

References :

1. **Rickman D.;** Luvall J. C.; Shaw J.; Mask P.; Kissel D. and Sullivan D. (2001) Precision Agriculture: Changing the Face of Farming; *Geotimes* News Note.
2. **Qu L., et al. 2005.** Visualizing adhesion-induced agglutination of Escherichia coli with mannosylated nanoparticles. J. Nanoscience and Nanotechnology, in press.
3. **Joseph, T. and M. Morrison.** 2006. Nanotechnology in Agriculture and Food: A Nanoforum Report. Institute of Nanotechnology. Available at http://www.nanoforum.org.
4. **Scott, N.R. 2005.** Nanotechnology and animal health. Rev. sci. tech. Off. int. Epiz. 24(1): 425-432.
5. **Moraru, C.I., et al. 2003.** Nanotechnology : A new frontier in food science. Food Technology. 57(12): 24-29.
6. **Lee, S.B. and C.R. Martin. 2002.** Electromodulated molecular transport in gold-nanotube membranes. J. Am. Chem. Soc. 124: 11850-11851.
7. **Roy, K., et al. 1999.** Oral gene delivery with chitosanBDNA nanoparticles generates immunologic protection in a murine model of peanut allergy. Nature Med. 5· 387-391.
8. **Warad, H.C. and J. Dutta. 2005.** Nanotechnology for agriculture and food systems – a view. Proc. 2nd International Conference on Innovations in Food Processing Technology and Engineering. Bangkok, Thailand.
9. **Zhang, W. 2003.** Nanoscale Iron Particles for Environmental Remediation: An Overview. J Nanoparticle Research. 5: 323-332.
10. **Blackmore, S.(1994).** Precision Farming: An Introduction. Outlook on Agriculture 23(4) 4, 275-280

পশ্চিমবঙ্গে সবজি উৎপাদনের চালচিত্র ও পরিকল্পনা

ড. মানিক গোপাল সোম ও ড. প্রণব হাজরা

একাদশ পঞ্চবার্ষিকী পরিকল্পনা রূপায়িত করার অনেক আগে থেকেই যোজনা কমিশন ও বৃহৎ পুঁজি সংস্থাগুলির পক্ষ থেকে ধারাবাহিকভাবে ভারতীয় কৃষিতে সব্জি, ফল ও ফুলের ব্যাপক চাষের মাধ্যমে আরও বৈচিত্র্যকরণ করার পক্ষে সওয়াল করা হচ্ছিল। দ্বাদশ পঞ্চবার্ষিকী পরিকল্পনায় এর থেকে এক ধাপ এগিয়ে সব্জি ও অন্যান্য উদ্যানজাত ফসলের বিপননে বিদেশী লগ্নির কথাও বলা হয়েছে। পুঁজিলগ্নির দিক থেকে সব্জি, ফল ও ফুলের উৎপাদন ও তার বিপনন ব্যবস্থাপনা অনেক বেশী সুবিধাজনক ও লাভজনক এবং একই সাথে শহরাঞ্চলের উচ্চ আয়ের লোকেদের জন্য অত্যাধুনিক সুপার মার্কেট, বিপনন ও যোগান শৃঙ্খলের পরিকাঠামো ব্যবহার করার জন্য এই উদ্যানজাত শস্যগুলি বিশেষ করে সব্জি খুবই উপযোগী। তাই বেসরকারী পুঁজি বিনিয়োগের জন্য সব্জি আদর্শ ফসল। বিভিন্ন অর্থনীতি বিষয়ক গবেষণায় আজ এটা স্পষ্ট যে সব্জি ও ফলের চাহিদা মূলতঃ রোজগারের স্থিতিস্থাপকতার উপর নির্ভরশীল। এই চিত্রপটের ভিত্তিতেই রিলায়েন্স, ভারতি, টাটা, গোয়েঙ্কা, ওয়ালমার্ট প্রভৃতি দেশী ও বিদেশী সুবৃহৎ শিল্প গোষ্ঠীগুলির পক্ষ থেকে সব্জি ও ফলের সরাসরি খুচরো বিপননের জন্য ব্যাপক উদ্যোগ নেওয়া হচ্ছে। এতে বিপনন ও যোগান শিল্পে দক্ষতা আসবে, কোন সন্দেহ নেই তবে গ্রামীন অর্থনীতিতে এই মূলধনী উদ্যোগ কতটা সুবিধাজনক প্রভাব ফেলবে তা ভবিষ্যতই বলবে। এতো গেল অর্থনীতির দিক।

এবারে সার্বিক পুষ্টির প্রয়োজনে সব্জির গুরুত্ব বিশেষভাবে উল্লেখ করা দরকার। ক্ষুধা আর অপুষ্টি আজ সারা বিশ্বের, বিশেষ করে উন্নয়নশীল দেশের সবচেয়ে মারাত্মক সমস্যা। আমরা বিশ্বাস করি ক্ষুধাহীন জীবনযাপন সবারই মৌলিক অধিকার তা সত্ত্বেও এই একবিংশ শতাব্দীর ভোর হয়েছে বিশ্বের ৮০ কোটি ক্ষুধার্ত মানুষের বিনিদ্র রজনী পেরিয়ে। আজ বিশ্বে ১৩০ কোটি মানুষের দৈনিক আয় এক ডলারেরও কম (৩৫-৪০ টাকা) এবং তারা বেশীরভাগ ক্ষেত্রেই অপুষ্টির শিকার। সারা পৃথিবীর ৭০ শতাংশের বেশী অপুষ্টিতে ভোগা মানুষের বাসস্থান দক্ষিণ ও দক্ষিণ পূর্ব এশিয়ার। ভারতের স্থান একেবারে নীচের দিকে। সম্প্রতি কাউন্সিল ফর সোসাল ডেভেলপমেন্টের তথ্য অনুযায়ী ২৬ কোটি ভারতীয়র অবস্থান দারিদ্র সীমার নীচে এবং তার মধ্যে ১৯.৩ কোটি মানুষ গ্রামীন ভারতের বাসিন্দা। বর্তমানে ভারতবর্ষের সদ্যজাত শিশুদের ৪২ শতাংশই স্বাভাবিকের চেয়ে কম ওজনের, বিশ্বে সবচেয়ে বেশী। এটা লজ্জা পাবার সব পরিসংখ্যান। আমাদের মায়েদের অপুষ্টির চিত্র ভয়াবহভাবে প্রকট এই চিত্রে। দারিদ্রে, ধন ও খাদ্য বন্টনে চরম বৈষম্য ও দৈনন্দিন খাদ্যে কম দামী স্বাস্থ্য রক্ষাকারী খাদ্য, সব্জির খুবই অপ্রতুলতার (যা হওয়া উচিত মাথাপিছু ৩০০ গ্রাম প্রতিদিন, যার মধ্যে ১২৫ গ্রাম সবুজ সব্জি, ৭৫ গ্রাম আলু, মিষ্টি আলু, ওল জাতীয় সব্জি আর ১০০ গ্রাম অন্যান্য সব্জি) কারণে আজ ২১ কোটিরও বেশী ভারতবাসী ক্ষুধা ও অপুষ্টির শিকার। এই নিরীখে ভারত সবার আগে। আমাদের পরে আছে আফ্রিকার সাহারা অঞ্চল ও চীন যেখানে যথাক্রমে ২০ ও ১৪ কোটি ক্ষুধার্ত ও অপুষ্টিতে ভোগা লোক বাস করে। এটা ভাবার কোন কারণ নেই যে শুধু দুর্ভিক্ষ এলেই লোকে ক্ষুধা আর অপুষ্টির শিকার হয়। সরকারী তথ্য অনুযায়ী ভারতের এখন সব্জির এখন যা বাৎসরিক উৎপাদন তাতে মাথা পিছু ১৬০ থেকে ১৭৫ গ্রাম সব্জি খাওয়ার পরিমাণ দিনে মেরেকেটে ১৫০ থেকে ১৬০ গ্রাম। চরম বন্টন বৈষম্য ও একই সাথে সচেতনতার অভাব। এদেশে সামগ্রিকভাবে খুবই প্রকট। অপুষ্টিজনিত নিঃশব্দ মৃত্যুর হাত থেকে রক্ষা পেতে সব্জি মতকম দামী ও স্বাস্থ্যরক্ষাকারী খাবারের ব্যাপারে সচেতন হতে হবে ও অন্যাকে সচেতন করতে হবে।

বর্তমান জাতীয় কৃষি ঃ

বিভিন্ন উদ্যানজাত ফসলের বিস্তারের মাধ্যমেই সুচারুরূপে কৃষি বৈচিত্র্য সাধিত হওয়া সম্ভব। সারা পৃথিবী তথা ভারতবর্ষেও সব্জি শস্য উদ্যানজাত ফসলগুলির মধ্যে অন্যতম যার বিপুল আভ্যন্তরীন ও বৈদেশিক চাহিদা আছে। মানুষের সার্বিক পুষ্টি, গ্রামীণ ক্ষেত্রে কর্মসংস্থান ও কৃষিভিত্তিক শিল্প স্থাপনের নিরিখে সব্জি শস্য উৎপাদন ও তার সুচারু বিপণন ব্যবস্থা বিশেষ গুরুত্বপূর্ণ। সামগ্রিক কৃষি ও তার বর্তমান প্রেক্ষাপট বিষয়ে কিছুটা আলোকপাত না করলে কোনো শস্য উৎপাদনের চালচিত্রই ঠিকভাবে বিবৃত করা যায় না, তাই এই প্রসঙ্গের অবতারণা।

আমরা যেভাবেই উন্নয়নের কথা বলি না কেন, বা যে বলেই বলিয়ান হই না কেন আমাদের তিনটি প্রধান চর্চিত ও উদ্বেগের বিষয় হলো পুষ্টি, সুঠাম স্বাস্থ্য ও প্রভূত কর্মশক্তি। তাই পর্যাপ্ত ও সুষম খাদ্য যোগানের ব্যবস্থা কৃষিবিজ্ঞানীসহ রাজনীতিবিদ, অর্থনীতিবিদ, পরিসংখ্যানবিদ্, সমাজবিজ্ঞানী এবং সর্বোপরি সবারই ভাবনার বিষয়। তাই পর্যাপ্ত খাদ্য উৎপাদন ও তার যোগানের পরিকল্পনা এবং তার সঠিক রূপায়নই রাষ্ট্রযন্ত্রকে প্রধানতঃ প্রভাবিত করে। স্বাভাবিকভাবেই স্বাধীনোত্তর ভারতে কৃষিবিজ্ঞানের বিকাশ ও তার প্রয়োগের মাধ্যমে উন্নত কৃষিব্যবস্থা পরিচালনাই হলো সবচেয়ে উল্লেখযোগ্য ও জনমুখী পরিকল্পনা। এখনও কৃষি উন্নয়নই দেশের তথা রাজ্যের অর্থনীতি চাঙ্গা করার অন্যতম চাবিকাঠি। সম্প্রতি ৩৫টি দেশের লোকসংখ্যা নিয়ে গবেষণা করে প্রমাণিত হয়েছে যে জনপ্রতি এক শতাংশ মোট আভ্যন্তরীণ কৃষি উৎপাদন বাড়লে সবচেয়ে দরিদ্র মানুষের আয় বাড়ে ১.৬ শতাংশ। তাই স্বাভাবিকভাবেই ভারতবর্ষের বর্তমান মুদ্রাস্ফিতি বাড়ার মূল কারণ হল, কৃষি পণ্যের যোগানভিত্তিক সমস্যা। রিজার্ভ ব্যাঙ্কের রিপোর্ট অনুযায়ী বর্তমান মুদ্রাস্ফিতির একটা বড় কারণ হল অত্যাবশক খাদ্যসামগ্রীর মূল্যবৃদ্ধি। চলতি আর্থিকবর্ষে দেশের মোট আভ্যন্তরীণ উৎপাদনের মাত্র ১৮.৫ শতাংশ কৃষিক্ষেত্রের দখলে থাকলেও ভারতের ৬০ শতাংশের বেশী মানুষের জীবনযাত্রা কৃষিনির্ভর। তাই সহজেই বোঝা যায় দেশের অর্থনীতির ওঠা-পড়া কৃষিক্ষেত্রের সামগ্রিক উন্নয়নের উপর কতটা নির্ভরশীল। বর্তমান অর্থবর্ষের আর্থিক সমীক্ষার দেখানো কৃষি উৎপাদন বৃদ্ধির নগন্য ২.৭ শতাংশ হার দেশকে কঠিন সমস্যার দাঁড় করিয়েছে। ঝিমিয়ে পড়া কৃষিক্ষেত্রকে ফের চাঙ্গা না করতে পারলে একদিকে যেমন কৃষিনির্ভর গ্রামীণ মানুষদের আয় কমে যাবে আবার সামগ্রিকভাবে খাদ্যের চাহিদাতেও টান পড়বে।

বর্তমান আর্থিক সমীক্ষায় কৃষিক্ষেত্রে সামগ্রিকভাবে পিছিয়ে পড়ার জন্য দায়ী করা হয়েছে এইক্ষেত্রে স্বল্প বিনিয়োগ, উন্নত বীজ প্রতিস্থাপনের কম হার, সার ব্যবহারের অসামঞ্জস্য, বিশেষ সুবিধা বা 'ইনসেন্টিভ' এব বেঠিক ব্যবস্থা, বর্ধিত কৃষিপণ্যের দাম, উৎপাদিত ফসলের দাম কমে যাওয়া ও সর্বোপরি প্রকৃতির বিরূপতা। কৃষকদের আত্মহত্যার মিছিলে অবশেষে পশ্চিমবঙ্গেও সামিল হয়েছে। কৃষিক্ষেত্রে বিনিয়োগের ছবিটা একদমই আশাবঞ্জক নয়। নব্বই এর দশকের শেষের দিকে কৃষিক্ষেত্রে সংগঠিত মূলধনের পরিমাণ মোট আভ্যন্তরীণ উৎপাদন বা জি.ডি.পি এর ২.২ শতাংশ থাকলেও ২০০৫-০৬ অর্থবর্ষে তা কমে দাঁড়িয়েছে ১.৯ শতাংশ এবং এটা আরও কমছে। কৃষি ব্যবস্থাপনার উন্নয়নের জন্য সরকারি লগ্নি কমে যাওয়ার ফলেই এই হ্রাস। এটা বলার অপেক্ষা রাখে না যে দেশের অর্থনীতি স্থিতিশীল করার লক্ষ্যে ঝিমিয়ে পড়া বিভিন্ন কৃষিক্ষেত্রকে চাঙ্গা করার জন্য সরকারি স্তরে পরিকল্পনা ও তা বাস্তবায়িত করার লক্ষ্যে উপযুক্ত ব্যয়বরাদ্দ ও ব্যবস্থাপনায় প্রভূত উন্নতি সাধন করা প্রয়োজন।

কম উৎপাদনশীলতা অন্যতম বৈশিষ্ট্য ঃ

ভারতীয় কৃষিতে হেক্টর বা একর প্রতি জমিতে কম উৎপাদন এখন এক স্বাভাবিক বৈশিষ্ট্য হয়ে দাঁড়িয়েছে। তা সত্ত্বেও সারা দেশ তথা এ রাজ্যে সব্জি উৎপাদনে বিপুল উন্নতি হয়েছে। স্বাধীনতার আগে দেশে

সব্জির মোট বার্ষিক উৎপাদন ছিল মাত্র ১৫ মিলিয়ন টন (১ কোটি ৫০ লক্ষ টন) এবং বহু বছর ধরে বার্ষিক গড় বৃদ্ধির হার ছিল মাত্র ০.৫ শতাংশ। বিগত ১৫ বছর সব্জি বিজ্ঞানে উন্নত গবেষণা, সংকরজাত কিছুটা হলেও প্রতিস্থাপন ও কিছু সরকারী ও বেসরকারী কর্মপন্থা ও তাঁর প্রায়োগিক দ্রুততার কারণেই পাঁচগুণ বেশী হারে (২.৫ শতাংশ) বৃদ্ধি পরিলক্ষিত হয়েছে। ফলতঃ দেশের বর্তমান মোট সব্জির (আলু ধরে) উৎপাদন ১৩০ মিলিয়ন টন (১৩ কোটি ৩৭ লক্ষ টন)। কম উৎপাদনশীলতা সত্ত্বেও আমরাই বিশ্বের দ্বিতীয় বৃহত্তম সব্জি উৎপাদনকারী দেশ চীনের পরেই এবং ভারতে বর্তমানে সারা বিশ্বের ১১.৫ শতাংশ সব্জি উৎপাদিত হয়।

সারা বিশ্বের প্রধান সব্জি উৎপাদনকারী দেশ

দেশ	বিশ্বের শতকরা উৎপাদন
চীন	৪৬.১
ভারত	১১.৫
আমেরিকা	৪.৭
তুর্কি	৩.১
ইটালী	২.০
মিশর	১.৮
রাশিয়া	১.৮
জাপান	১.৬
স্পেন	১.৫
ইরান	১.৫
অন্যান্য দেশ মিলে	২৪.৪

সূত্র ঃ ন্যাশনাল হরটিকালচার বোর্ড, ইন্ডিয়ান হর্টিকালচার ডাটাবেস – ২০০৫

বিগত এক দশক ভারতে সব্জির (আলু ধরে) এলাকা, উৎপাদন ও উৎপাদনশীলতা

বছর	এলাকা (.০০০ হেক্টর)	উৎপাদন (.০০০ টন)	উৎপাদনশীলতা (.০০০ টন প্রতি হেক্টরে)
১৯৯৫-৯৬	৫৩৩৫.৪৫	৭১৫৯৪.৬০	১৩.৪২
১৯৯৬-৯৭	৫৫১৫.৪০	৭৫০৭৪.৪০	১৩.৬১
১৯৯৭-৯৮	৫৬০৭.১০	৭২৬৮৩.১০	১২.৯৬
১৯৯৮-৯৯	৫৮৮৬.০০	৮৭৫৩৬.০০	১৪.৯২
১৯৯৯-০০	৫৯৯১.৪০	৯০৮২৩.০০	১৫.১৬
২০০১-০১	৬২৫০.১০	৯৩৮৪৯.৯০	১৫.০২
২০০১-০২	৬১৫৫.৭০	৮৮৬২২.০০	১৪.৪০
২০০২-০৩	৬০৯১.৭০	৮৪৮১৫.৩০	১৩.৯২
২০০৩-০৪	৬৩০৮.৯০	৯৩১৬৫.০০	১৪.৭৭
২০০৪-০৫	৬৭৫৫.৬০	১০১৪৩৩.৫০	১৫.০১
এক দশকে শতকরা বৃদ্ধি	+২৬.৬০	+৪১.৬৭	+১১.৮৪

সূত্র ঃ ন্যাশানাল হরটিকালচার বোর্ড, ইন্ডিয়ান হর্টিকালচার ডাটাবেস – ২০০৫

পশ্চিমবঙ্গে সবজি উৎপাদনের চালচিত্র ও পরিকল্পনা

ভারতে সব্জি উৎপাদনের ২০১০ সালের চালচিত্র যদি ১৯৮০ সালের নিরিখে ধরি তবে সত্যিই অবিশ্বাস্য উন্নতি হয়েছে কারণ বিগত ৩০ বছরে সব্জির জন্য জমির পরিমাণ বেড়েছে ৬১.২৯ শতাংশ। (৪৯.৫০ লক্ষ হেক্টর থেকে ৭৯.৮৪ লক্ষ হেক্টর) কিন্তু সব্জির (আলু ধরে) উৎপাদন বেড়েছে ২০৪.৩২ শতাংশ (৪ কোটি ৪০ লক্ষ টন থেকে ১৩ কোটি ৩৭ লক্ষ টন)। দেশের অন্যান্য রাজ্যের মত পশ্চিমবঙ্গে বিগত ৩০ বছরে সব্জি চাষের ব্যাপকতা ও উৎপাদনে প্রভূত উন্নতি হয়েছে। রাজ্যে ক্ষুদ্র সেচ ব্যবস্থার উন্নতি, নগরায়নের বৃদ্ধি ঘটা, আর্থিক উন্নতি কিছুটা হলেও, ঘটার জন্য চাহিদা বৃদ্ধিতে ক্ষুদ্র ও প্রান্তিক চাষীদের কাছে আজ সব্জি চাষ লাভজনক হিসাবে প্রতিষ্ঠিত। এ রাজ্যের নিরিখে সব্জি চাষের বৃদ্ধি ঘটা আরো অর্থপূর্ণ কারণ চাষের ব্যাপকতার পশ্চিমবঙ্গ সবার আগে। এ রাজ্যে আলুবাদে ১০ শতাংশ কৃষিজমিতে সব্জি চাষ হয় এবং আলু ধরে ১৪ শতাংশ জমিতে সব্জি চাষ হয়। জাতীয় নিরিখে সব্জির জমি মোট কৃষিজমির ৪ শতাংশরেও কম। মোট কৃষি উৎপাদনের দ্বিতীয় বৃহত্তম অংশীদার হল সব্জি (২৫ শতাংশ আলু ছাড়া)। আলু ধরলে সব্জিই কৃষি উৎপাদনের বৃহত্তম অংশীদার (৪০ শতাংশ)।

একদশ পঞ্চম বার্ষিক পরিকল্পনায় বছরে পশ্চিমবঙ্গে সব্জির (আলু ধরে) এলাকা, উৎপাদন ও উৎপাদনশীলতা

বছর	এলাকা (.০০০ হেক্টর)	উৎপাদন (.০০০ টন)	উৎপাদনশীলতা (.০০০ টন প্রতি হেক্টরে)
২০০৬-০৭	১২৪৪.৩	১৯০১৯.২	১৫.২৮
২০০৭-০৮	১৩১১.৭	১৭১৪০.০	১৩.০৬
২০০৮-০৯	১৩২৩.৬	২২৭০৪.৩	১৭.১৫
২০০৯-১০	১৩০২.৭	২১৯০৬.৫	১৬.৮১
গত পাঁচ বছরে শতকরা বৃদ্ধি ও হ্রাস	+৪.৬৯	+৪১.৬৭	+১১.৮৪

সূত্র ঃ ন্যাশনাল হর্টিকালচার বোর্ড, ইন্ডিয়ান হর্টিকালচার ডাটাবেস – ২০১০

যদিও আলু ধরে, মোট সব্জি উৎপাদনে পশ্চিমবঙ্গ এখন দুনম্বরে, কিন্তু উৎপাদনশীলতা নিরিখে চাষের অগ্রগতি আশাব্যঞ্জক নয়। সারা ভারতে যখন সব্জির গড় উৎপাদন বেড়েছে বিগত দশ বছরে (২০০১-০২, ২০০৯-১০) ৫০.৯১ শতাংশ তখন পশ্চিমবঙ্গে বিগত পাঁচ বছরে উৎপাদন বেড়েছে মাত্র ১৫.১৭ শতাংশ। সবচেয়ে উদ্বেগের কথা হল পশ্চিমবঙ্গের সব্জির উৎপাদনশীলতা কিছুটা হলেও, হ্রাস পাওয়া যা এমনিতেই অন্যান্য অনেক রাজ্যের তুলনায় কম।

সব্জির (আলু ধরে) বর্তমান (২০১০) উৎপাদন ও উৎপাদনশীলতায় প্রথম দশটি রাজ্য

বছর	এলাকা (.০০০ হেক্টর)	উৎপাদন (.০০০ টন)	উৎপাদন (.০০০ টন)
উত্তরপ্রদেশ	১০২০.০০	২২৪৩৫.৭	২২ ০
পশ্চিমবঙ্গ	১৩০২.৭০	২১৯০৬.৬	১৬.৮
বিহার	৮৩৬.৬০	১৩৯০৬.২	১৬.৬
উড়িষ্যা	৬৯৪.২০	৮৩৯৩.৬	১২.৯
তামিলনাড়ু	২৬৩.৭০	৭৬২৭.৭০	২৮.৯

গুজরাট	৪০৬.৮০	৭২৫৫.০০	১৭.৮
কর্ণাটক	৪৪১.২০	৭০৮২.২০	১৬.১
মহারাষ্ট্র	৪৫১.৮০	৬১৭২.৬০	১৩.১
অন্ধ্রপ্রদেশ	৩৩১.৫০	৫৪২৬.২০	১৬.৪
আসাম	২৫৫.২	৪৫৬৮.৯০	১৭.৯
মোট (সারা দেশে)	৭৯৮৪.৮০	১৩৩৭৩৭.৬০	১৬.৭

সূত্র ঃ ন্যাশনাল হর্টিকালচার বোর্ড, ইন্ডিয়ান হর্টিকালচার ডাটাবেস – ২০১০

এমতাবস্থায় আগামী দশকে পঞ্চবার্ষিকী পরিকল্পনার সময় পর্বে বিশেষ প্রযুক্তিগত আর্থিক, পরিকাঠামোগত, খাদ্য প্রক্রিয়াকরণ শিল্প ও সর্বোপরি বিপননগত বিশেষ ব্যবস্থা গ্রহণ করে উৎপাদনশীলতা বাড়াতে সাহায্য না করতে পারলে পশ্চিমবঙ্গে সব্জির উৎপাদন অবশ্যম্ভাবী কমে যাবে, কারণ সব্জির মোট উৎপাদন বাড়ানোর তাগিদে আরও বেশী জমি সব্জি চাষের আওতাভুক্ত করা প্রায় অসম্ভব। সর্বব্যাপী বাজার অর্থনীতির নিরিখে পুঁজির আহ্বান ও তার নিবেশ ও বিকাশের মাধ্যমে বিস্তৃত নগরায়ন ও পছন্দমাফিক জমিতে শিল্পায়ন হওয়াই স্বাভাবিক, তা সে যেখানেই হোক না কেন। ফলতঃ কৃষিজমি কমে যাওয়া এক অনুবর্ত্তি ঘটনাক্রম মাত্র। পতিত বা নষ্ট হতে চলেছে এমন জমি চাষের আওতায় এনে মূল কৃষিজমি স্থিতিশীল রাখা বা বাড়ানো সম্ভব, তবে এই সব জমি সবসময় সব্জি চাষের অনুকূল নাও হতে পারে। তাই সুনির্দিষ্ট পদক্ষেপের মাধ্যমে সব্জির উৎপাদনশীলতা বাড়িয়েই মোট উৎপাদন বাড়ানোর পদক্ষেপ নিতে হবে। বস্তুতঃ অধিক উৎপাদনশীলতা এবং কৃষির উপর নির্ভরশীল অনেক কম লোকসংখ্যাই উন্নত দেশগুলির আধুনিক কৃষির মূল বৈশিষ্ট্য।

এটা ঠিক যে একদিকে যেমন কমছে দেশের মোট আভ্যন্তরীণ উৎপাদনে কৃষিক্ষেত্রের অংশীদারী (চাল, গম, ডালশস্য ও তৈলবীজের উৎপাদন উল্লেখযোগ্যভাবে না বাড়া অথবা উৎপাদন কমে যাওয়ার এর প্রধান কারণ), অন্যদিকে তেমনই বেড়ে গিয়েছে অত্যাবশ্যক কৃষি পণ্যের দাম। সর্বোপরি এ ক্ষেত্রে স্বল্প আয়ের ফলে চাহিদা যেভাবে থিতিয়ে গিয়েছে তাতে ঝিমিয়ে পড়েছে অন্যান্য ক্ষেত্রে বৃদ্ধির সম্ভাবনা। এমতাবস্থায় সব্জি সমেত সমস্ত পণ্যের উৎপাদনশীলতা বাড়ানোর সুনির্দিষ্ট পরিকল্পনা না করে যদি শুধু কৃষির উপর নির্ভরশীল জনসংখ্যা কমানোর কথা ভাবা হয় তবে অবধারিতভাবে টান পড়বে কৃষিপণ্যের ভাঁড়াবে, ফলে কৃষিপণ্যের দাম নাগালের বাইরে গিয়ে সমস্যা সমস্যা আরও জটিল করে তুলবে।

সব্জি	বিশ্বে গড় উৎপাদনশীলতা (টন প্রতি হেঃ)	উৎপাদন সম্ভাব্যতা (টন প্রতি হেঃ)	ভারতে গড় উৎপাদনশীলতা (টন প্রতি হেঃ)	পশ্চিমবঙ্গে গড় উৎপাদনশীলতা (টন প্রতি হেঃ)	বিশ্বে সর্বোচ্চ উৎপাদনশীলতা (টন প্রতি হেঃ)
টম্যাটো	২৬.৬৯	৬০–৮০	১৪.০৭	১৭.১৬	৭০.৪৫ (আমেরিকা)
বেগুন	১৭.৪৮	৪০–৫০	১৬.০৮	১৮.০৩	৩৪.৩ (জাপান)
লংকা (কাঁচা)	১৪.৪০	৩০–৪০	৯.১৮	৫.৮০	৪৪.৫ (স্পেন)
ট্যাঁড়স	৬.৪৭	১৫–২০	৯.৫৯	১০.৯৩	১৭.৭৮ (জর্ডন)
মটর শুটি	৮.৩৫	১৮–২০	৯.১৪	৫.৯৭	২০.০০ (লিথুয়ানিয়া)
খরমুজ	২০.৯৫	৩০–৪০	২০.৪৮	–	৪৫.৩৩ (সাইপ্রাস)
বিভিন্ন কুমড়া	১২.৯৭	২৫–৩০	৯.৭২	১০.৭০	৪১.৩৩ (ইসরায়েল)
গোত্রিয় সব্জি					
শশা	১৬.৯৮	৪০–৫০	৬.৬৭	–	৬৭.৬৭ (কোবিযা)

তরমুজ	২৭.১৩	৩০-৪০	১২.৭৫	১১.৭৫	৪০.৯৬ (স্পেন)
বাঁধাকপি	২১.১০	৩০-৪০	২১.৪৩	২৬.৫৩	৪০.৯৬ (স্পেন)
ফুলকপি	১৮.৩৬	৩৫-৪০	১৭.১৪	২৫.৩৮	৪২.৫৯ (জাপান)
পিঁয়াজ	১৭.৫৩	৪০-৫০	১০.৩৪	১২.৬৫	৪৫.২৫ (নিউজিল্যান্ড)
রসুন	১২.৩৭	১৫-২০	৪.১৭	-	৬০.৩৩ (কোরিয়া)
গড়			১৬.০৭	১৬.৮	

উপরের চিত্র থেকে এটা স্পষ্ট যে, সারা বিশ্বের সব্জির বর্তমান গড় উৎপাদনশীলতা নিরিখে ভারত তথা পশ্চিমবঙ্গ কতটা পিছিয়ে আছে আর বিভিন্ন উল্লিখিত দেশগুলির উৎপাদনশীলতা মনে হয় যেন স্বপ্ন। এটা আশমান থেকে পড়ে পাওয়া কোন জাদু দন্ডে হয়নি। এর জন্য সঠিক ও উন্নত জিন প্রযুক্তির রূপায়ন (সংকর বা উচ্চফলশীল জাতের বীজ) ও সুক্ষ-নির্দেশী কৃষিকার্য (Precision farming) পরিচালনা যা আমাদের দেশের কৃষিক্ষেত্রে এখনও ধারণা সংক্রান্ত ব্যাপার (Concept) হিসাবেই আছে, প্রয়োগ তো দুরঅস্ত।

সব্জির (আলু ধরে) সার্বিক উৎপাদনশীলতার নিরিখে পশ্চিমবঙ্গের স্থান দেশে অষ্টম (১৬.৮ টন হেক্টর প্রতি) এবং জাতীয় গড় উৎপাদনশীলতার (১৬.৭ টন হেক্টর প্রতি) প্রায় সমান। বিভিন্ন সব্জির বিশেষ করে বাঁধাকপি, ফুলকপি, টম্যাটো, বেগুন, ঢ্যাড়স, পিঁয়াজ ইত্যাদির সব্জির উৎপাদশীলতা জাতীয় গড়ের চেয়ে বেশ কিছুটা এগিয়ে, আবার মটরশুঁটি, তরমুজ, কাঁচা লংকার উৎপাদনশীলতায় আমরা জাতীয় গড়েরও নীচে।

কিন্তু সত্যি সত্যিই যদি আধুনিক কৃষি প্রযুক্তির প্রয়োগে পশ্চিমবঙ্গে সব্জির উৎপাদনশীলতা উল্লেখযোগ্যভাবে বাড়াতে হয় তবে উৎপাদনশীলতার লক্ষ্যমাত্রা অবশ্যই জাতীয় গড় হওয়া উচিত নয়, উচিত তামিলনাড়ু (২৮.৯ টন হেক্টর প্রতি) ও কেরালার (২৩.১ টন প্রতি হেক্টরে) উৎপাদনশীলতা। পশ্চিমবঙ্গে আলুর উৎপাদনশীলতা স্থিতিশীলভাবে প্রায় ২০ টন হেক্টর প্রতি তাই অন্যান্য সব্জির উৎপাদনশীলতার লক্ষ্যমাত্রা ২০২০ সাল নাগাদ অবশ্যই হওয়া উচিত ২৫ টন প্রতি হেক্টরে।

আগেই দেখানো হয়েছে যে, ২০০৬-০৭ থেকে ২০০৯-১০ পর্যন্ত পশ্চিমবঙ্গে সব্জি চাষের এলাকা বেড়েছে মাত্র ৪.৬৯ শতাংশ এবং উৎপাদনশীলতা বেড়েছে মাত্র ১০ শতাংশ। এমতাবস্থায় হঠাৎ করে সব্জি চাষের এলাকা ও উৎপাদনশীলতা বেড়ে যাওয়ার আশা করা ঠিক যুক্তিগ্রাহ্য নয়। বর্তমান প্রাসঙ্গিক দৃষ্টিভঙ্গিতে কৃষিজমি কমে যাওয়া বা স্থিতিশীল থাকার সম্ভাবনা যেখানে প্রকট সেই অবস্থায় উৎপাদনের লক্ষ্যমাত্রা পূরণের জন্য আরও বেশী করে কৃষিজমি সব্জি চাষের আওতাভুক্ত করার পরিকল্পনা বাস্তবায়িত হবার সম্ভাবনা খুবই কম যদি না পশ্চিমবঙ্গের পশ্চিমাঞ্চলের লাল কাঁকুড়ে মাটি ও সুন্দরবনের আঠালো ও নোনা মাটি অঞ্চলে সব্জি চাষ ব্যাপকভাবে বাড়ানোর জন্য নির্দিষ্ট দীর্ঘমেয়াদি বিশেষ করে সেচ বিষয়ক পরিকল্পনা না নেওয়া হয়। তবে উন্নয়ন পরিকল্পনাকে প্রভাবশালী ও গতিশীল করার লক্ষ্যে আধুনিক প্রযুক্তি প্রয়োগে উৎপাদনশীলতা বাড়ানোর লক্ষ্যমাত্রাই ধার্য করা উচিত। পরিকল্পনার সময় এটা মনে রাখা দরকার যে, ভারতবর্ষে তথা পশ্চিমবঙ্গের সব্জির কম উৎপাদনশীলতা জন্য দায়ী স্বল্প বিনিয়োগ, উন্নত বীজ প্রতিস্থাপনের কম হার, সার ব্যবহারের অসামঞ্জস্য, অপর্যাপ্ত সেচ ব্যবস্থা, খাদ্য প্রক্রিয়াকরণ শিল্পের অভাব, পরিকাঠামোহীন ও অদক্ষ বিপনণ ব্যবস্থা ইত্যাদির মতো একাধিক বিষয়।

উৎপাদনের লক্ষ্যমাত্রা ঃ

সব্জির ব্যবহার জনগনের অর্থনৈতিক অবস্থা, যোগান ও সব্জির খাদ্যগুণ সম্বন্ধে সম্যক্ অবহিত হবার উপর নির্ভর করে। তাই গ্রামীণ অঞ্চলে সব্জির ব্যবহার শহরাঞ্চলের চেয়ে অনেক কম। সুষম খাদ্যের

জন্য দৈনিক মাথা পিছু ৩০০ গ্রাম সব্জির প্রয়োজন মেটাতে ভারতে আগামী দিনে ভারতে চাহিদা হবে এই পরিমাণ।

সময় পর্ব	সব্জির বাৎসরিক চাহিদা (কোটি টন)
২০০৫-০৬	১০.৮১
২০১১-১২	১২.৮০
২০২০-২১	১৬.০০

এই চাহিদার সাথে অন্ততঃ ১০ শতাংশ রপ্তানী ও ১০ শতাংশ প্রক্রিয়াকরণের লক্ষ্যমাত্রা ধার্য করলে সব্জির চাহিদা হবে ২০১১-১২ নাগাদ ১৫.৩৬ কোটি টন ও ২০২০-২১ নাগাদ ১৯.২০ কোটি টন।

জনগণের শুধুমাত্র সুষম আহার যোগানের জন্য পশ্চিমবঙ্গে মোট সব্জির (আলু সমেত) চাহিদা এইরকম হবে।

সময় পর্ব	জনসংখ্যা (আনুমানিক, কোটি)	সব্জির বাৎসরিক চাহিদা (কোটি টন)
২০০৫-০৬	৮.১৮	০.৮৮
২০১১-১২	৮.৪৮	০.৭২
২০২০-২১	১০.৩৪	১.০৪

পশ্চিমবঙ্গের এই চাহিদার সাথে অন্ততঃ ১০ শতাংশ রপ্তানী প্রক্রিয়াকরণের লক্ষ্যমাত্রা ধার্য করলে সব্জির চাহিদা হবে ২০১১-১২ নাগাদ ১.০৫ কোটি টন ও ২০২০-২১ সাল নাগাদ ১.২৪ কোটি টন। সরকারী তথ্যের নিরিখে চাহিদার তুলনায় পশ্চিমবঙ্গের আলু সমেত মোচ সব্জির বাৎসরিক উৎপাদন (১ কোটি ৮১ লক্ষ টন) অনেক বেশী। আবার বিপরীতমুখিভাবে এটাও দেখি পশ্চিমবঙ্গের অনেক গ্রামীণ এলাকায় মাথাপিছু সব্জির ব্যবহার দিনে ১০০ গ্রামেরও কম। এই অসংগতিপূর্ণ তথ্যাবলী নির্দিষ্টভাবে সব্জির এলাকা, উৎপাদন, উৎপাদনশীলতা, মাথাপিছু সব্জির ব্যবহার, অন্য রাজ্য ও বিদেশে সব্জি রপ্তানি সংক্রান্ত বিশদ তথ্য উদঘাটন ও তার প্রতিবেদন প্রকাশের উপর গুরুত্ব আরোপ করছে। নির্ভরযোগ্য তথ্য ছাড়া সব্জির চাহিদা, উন্নতি, উৎপাদন ও বিপণন সম্বন্ধে সঠিক ও কার্যকরী পরিকল্পনা করা সম্ভব নয়। তবে হিসাবের গরমিল যাই ধরে নেওয়া হোক না কেন, পশ্চিমবঙ্গে সব্জির চাষের ব্যাপ্তি ও প্রভূত উৎপাদনের চিত্র স্পষ্ট ও সর্বভারতীয় ক্ষেত্রে স্বীকৃত। এমতাবস্থায় কয়েকটি সুনির্দিষ্ট পরিকল্পনা নেওয়া জরুরী।

(১) বিশেষ সব্জি অঞ্চল চিহ্নিত করে সংরক্ষণ ও বিপণন ব্যবস্থার পরিকাঠামো গড়ে তোলা।
(২) উৎপাদনশীলতা বৃদ্ধি ও ফসলের গুণমান বাড়ানো।
(৩) বাজারের প্রয়োজন অনুযায়ী উৎপাদন এবং উৎপাদিত পণ্যের বাজারকে বিস্তৃত করা।
(৪) অন্য রাজ্য ও বিদেশে সব্জি রপ্তানির উপর বিশেষ গুরুত্ব দেওয়া।

সব্জির সামগ্রিক উৎপাদন, উৎপাদনশীলতা ও গুণমান বৃদ্ধির জন্য বিভিন্ন সুপারিশসমূহ সংক্ষেপে উল্লেখ করা হয়েছে।

(১) সব্জি বিজ্ঞানের বিভিন্ন বিষয়ে ধারাবাহিক ও কার্যকরী গবেষণা করা ও উন্নত জাতসমূহ ও প্রযুক্তি কৃষকের কাছে পৌঁছে দেওয়া।

(২) সংকর ও উচ্চফলশীল জাতের এলাকা বৃদ্ধি করা যাতে অন্ততঃ ৩৫-৪০ শতাংশ সব্জির জমিতে অনুন্নত স্থানীয় জাতসমূহ প্রতিস্থাপিত হয়।

(৩) নতুন সংকর/উচ্চফলনশীল/নির্দিষ্ট গুনান্বিত জাত ও সুক্ষ নির্দেশী (precision farming) প্রযুক্তি সংক্রান্ত প্রদর্শনের (frontline demonstration) ধারাবাহিক ব্যবস্থা।

(৪) সরকারী ও বেসরকারী যৌথ অথবা সমবায়ী উদ্যোগে বীজগ্রাম গড়ে তোলার প্রত্যয়ে উন্নত জাতসমূহের মুক্ত অবস্থায় উৎপাদিত (open pollinated) বীজ ও সংকর বীজ উৎপাদনের ব্যবস্থা করা।

(৫) কৃষকের সক্রিয় অংশগ্রহণের মাধ্যমে বিভিন্ন সব্জির জীববৈচিত্র্য সংরক্ষণ করা।

(৬) সব্জি শস্যের বৈচিত্র্য বাড়িয়ে কিছু নতুন ও তুলনামূলকভাবে কম উৎপাদিত সব্জি যেমন, সুইট কর্ণ, বেবি কর্ণ, সজনে, লিক, বানচিং পিঁয়াজ, ওয়েলস্ পিঁয়াজ, ব্রকোলি, ব্রাসেলস স্প্রাউটস্, চাইনিস বাঁধাকপি, পটল, কাঁকরোল, মিঠা করলা, কুঁদরি, ফ্যাবা বিন, লিমা বিন, উইঙ্গবিন, সোর্ডবিন, ভেলবেট বিন ইত্যাদি সব্জির এলাকা বাড়ানো।

(৭) **সব্জি উৎপাদনে উচ্চ প্রযুক্তির ব্যবহার ঃ**

- উচ্চ প্রযুক্তিতে চারা তৈরী করা।
- পলিহাউসের ভিতর সুরক্ষিত অবস্থায় সব্জি উৎপাদন।
- সেচ ব্যবস্থায় ড্রিপ সেচের ব্যবহার।
- জমিতে জৈব অথবা স্বাভাবিকভাবে ক্ষয়িষ্ণু (degradable) জিনিস দ্বারা আচ্ছাদনের (mulching) ব্যবস্থা করা।
- নির্দিষ্ট জাতসমূহ ও সুরক্ষিত উৎপাদন প্রযুক্তি প্রয়োগে অসময়ে সব্জি উৎপাদন বাড়ানো।

(৮) **সমন্বিতভাবে উদ্ভিদ খাদ্যের যোগান দেওয়া ঃ**

- বিভিন্ন জৈবসার. কেঁচো জাত জৈবসার ও জীবাণু সারের ব্যবহার সুনিশ্চিত করা।
- প্রাকৃতিক সম্পদকে সঠিকভাবে কাজে লাগিয়ে পরিবেশের ভারসাম্য রক্ষা করা।
- মাটির স্বাস্থ্য ও তার জীববৈচিত্র্যের সংরক্ষণ।
- মাটি পরীক্ষার ফল অনুযায়ী সঠিক অণুপাতে রাসায়নিক সার প্রয়োগ।

(৯) **সমন্বিতভাবে রোগ ও শত্রুপোকা দমন করা ঃ**

- রোগ ও শত্রুপোকার আবির্ভাবের অনুকূল আবহওয়া বা পরিবেশ সম্বন্ধে কৃষককে সম্যক্‌ভাবে ওয়াকিবহাল করানো।
- বিভিন্ন শস্য পরিচর্চা ও উৎপাদন ব্যবস্থাপনার যেমন – শস্য পর্যায়, উপযুক্ত সাথী ফসল চাষ, ফসল বোনা বা লাগানোর সময়ের হেরফের ইত্যাদির মাধ্যমে রোগ ও শত্রুপোকা দমনের ব্যবস্থা করা।
- শেষ অস্ত্র হিসাবে অপেক্ষাকৃত নিরাপদ রাসায়নিক কীটনাশক ব্যবহার করা।
- এই ব্যবস্থাপনার অনিবার্য শর্ত অনুযায়ী বিভিন্ন জৈব কীটনাশক ও কীটশত্রু দমনকারক পদার্থ কৃষকের কাছে সঠিক সময়ে পৌঁছানোর বন্দোবস্ত করা।

(১০) বিশেষ সব্জি উৎপাদন অঞ্চল গড়ে তোলা যেখানে বিপণন, সংরক্ষণ ও যোগান শৃঙ্খল সম্বন্ধিয় সব পরিকাঠামো থাকবে।

(১১) শহর, শহরতলী ও গ্রামাঞ্চলের সব্জি মাণ্ডি ও হাটগুলির সংস্কার সাধন করা ও নতুন করে আরও বেশী গড়ে তোলা।

(১২) সব্জি উৎপাদন, সংরক্ষণ ও বিপণনে বেশী করে সরকারী ও বেসরকারী লগ্নির মাধ্যমে বেশী বিনিয়োগের বন্দোবস্ত করা।

(১৩) সব্জি উৎপাদন ও বিপণনের সাথে জড়িত মহিলাদের স্বনিযুক্তি প্রকল্পে ক্ষুদ্র ঋণ (microfinance) দানের ব্যবস্থা করা।

(১৪) সব্জি উৎপাদক ও তার বিপণনের সাথে জড়িত সবার জন্য সব্জির নির্দিষ্ট গুণমান ও নিরাপদভাবে উৎপাদন প্রযুক্তি সম্বন্ধে ব্যাপকভাবে প্রশিক্ষণের ব্যবস্থা করা।

(১৫) প্রাথমিক স্কুল পর্যায় থেকে শুরু করে বিভিন্ন শিক্ষাদান স্তরে এবং রেডিও টেলিভিশনের মাধ্যমে স্বাস্থ্য রক্ষা ও পুষ্টিবিধানে সব্জির গুরুত্ব ও সব্জি খাওয়ার অভ্যাস সম্পর্কিত বিভিন্ন সচেতনতা কর্মসূচী নেওয়া।

“সুরক্ষিত ও সুক্ষ নির্দেশী” প্রযুক্তির মাধ্যমে উচ্চ গুনমানের ও অসময়ের সব্জি উৎপাদন পদ্ধতি

ড. প্রণব হাজরা, ড. অরূপ চট্টোপাধ্যায় ও ড. মলয় কুমার সামন্ত

বর্তমান শহরকেন্দ্রিক অর্থনৈতিক উন্নয়নের ফলস্বরূপ দেশের অভ্যন্তরে ও বিদেশি রপ্তানির জন্য সব্জির চাহিদা আজ নিরবিচ্ছিন্ন ও সারা বৎসরব্যাপি। একদিকে জনবিস্ফোরণ, নগরায়ন ও শিল্পায়নের ফলে মাথাপিছু জমির পরিমান প্রতিনিয়ত কমছে শংকাজনক হারে, আবার অন্যদিকে উৎপাদন ব্যবস্থা শস্যের প্রগাঢ়ত্বের (cropping intensity) অগ্রগতির স্থিতাবস্থা দেখা যাচ্ছে। এমতাবস্থায় পলিথিন ছাউনির ভিতরে সব্জি উৎপাদনের পরিবেশ, বিশেষ করে তাপমাত্রা ও সেচ কিছুটা নিয়ন্ত্রণের মাধ্যমে বাইরের পরম্পরাগত খোলা জায়গায় উৎপাদনের চেয়ে অধিক গুনান্বিত, অসময়ে ও বেশীদিন ব্যাপী সব্জি উৎপাদন করে ভালো বাজার ধরার পরিকল্পনা আজ ভারতবর্ষের বিভিন্ন প্রান্তে জনপ্রিয় করানোর প্রয়োজন হয়েছে। পলিথিন ছাউনির ভিতর সব্জি উৎপাদন ব্যবস্থাকে “সুরক্ষিত উৎপাদন ব্যবস্থা” বলা হয়।

সুরক্ষিত ও সুক্ষ্ম নির্দেশী উৎপাদন ব্যবস্থার মূলনীতি ও ব্যবস্থাপনা ঃ

১) পলিথিন ছাউনির অভ্যন্তরস্থ জলবায়ুর সুবিধাজনক পরিবর্ত্তন ঘটিয়ে গাছের বৃদ্ধি, বিকাশ, ফলন ও ফসলের গুনমানের বৃদ্ধি ঘটানো।

২) পলিথিন ছাউনির ভিতর সূর্যলোকের প্রবেশ যতদূর সম্ভব নিখুঁতভাবে নিয়ন্ত্রণ করে গাছের বৃদ্ধি দীর্ঘায়িত বা ধারণক্ষণ করা। আমরা জানি সূর্যের আলোক শক্তির তড়িৎ চৌম্বকীয় ধর্মানুসারে বিভিন্ন তরঙ্গ দৈর্ঘ্য (wave length) আছে। আলোর বিভিন্ন তরঙ্গ দৈর্ঘ্যের মধ্যে ৪০০–৭০০ ন্যানোমিটার দৈর্ঘ্যের আলোক তরঙ্গ সালোক সংশ্লেষনের জন্য সবচেয়ে প্রয়োজনীয়। এর চেয়ে ছোট ১৫–৩৯০ ন্যানোমিটার দৈর্ঘ্যের অতিবেগুনী রশ্মি (ultraviolet ray) গাছের শারীরবৃত্তিয় কার্যের জন্য খুবই ক্ষতিকর। অতিবেগুনী রশ্মি সুস্থিত (UV-stabilized) পলিথিনের চাদর সূর্যলোকের অতিবেগুনী রশ্মি শুষে নিয়ে শস্য রক্ষা করে। বস্তুতঃ পলিথিনের ছাউনি প্রায় ৪০ শতাংশ সূর্যলোক ফিরিয়ে দেয় এবং প্রয়োজনীয় ৪০০–৭০০ ন্যানোমিটার দৈর্ঘ্যের আলোক তরঙ্গের প্রবেশ সুনিশ্চিত করে সালোকসংশ্লেষের কার্যক্ষমতা বাড়িয়ে উৎপাদন বাড়ায়।

৩) গাছের বৃদ্ধি ধারণক্ষম করে উৎপাদনের সর্বোচ্চ লক্ষ্যে পৌঁছানো। নাতিশীতোষ্ণ অঞ্চলে (temperate zone) ও গ্রীষ্মমন্ডল নিকটস্থ অঞ্চলে (sub-tropical zone) এর শীতকালে পলিথিন ছাউনির ভিতর তাপমাত্রা বৃদ্ধি পাওয়া ও অতিবেগুনী রশ্মির প্রবেশ নিশ্চিদ্র হবার দরুণ গাছের বৃদ্ধি হার ও ব্যাপ্তি (span) বেড়ে যাবার সুবাদে ফলন ও ফসলের গুণমান প্রভূত বৃদ্ধি পায়।

৪) “গ্রীণ হাউস এফেক্ট (green house effect) এর দরুণ পলিথিনের ছাউনির ভিতরের তাপমাত্রা বৃদ্ধি পাবার জন্য গাছের বৃদ্ধি ত্বরান্বিত হয়। দিনের বেলা যতটা সূর্যালোক অতিবেগুনী রশ্মি সুস্থিত পলিথিনের চাদরের মধ্যে দিয়ে ভেতরে প্রবেশ করে (প্রায় ৫৭ শতাংশ) তা শোষিত হয় গাছে, পলিথিনের ছাউনির মেঝে ও অন্যান্য কাঠামোয়। রাতে এই বস্তুসমূহ থেকেই অপেক্ষাকৃত অনেক বড় দৈর্ঘ্যের ইনফ্রারেড (Infrared) আলোক তরঙ্গ (৭৬০–২৫০০ ন্যানোমিটার) বিকীর্ণ (emit) হয়। এই ইনফ্রারেড তরঙ্গ পলিথিনের ছাউনির ভিতবের তাপমাত্রা বাড়িয়ে দেয় — একেই “গ্রীনহাউস এফেক্ট” বলে।

ভিতরের তাপমাত্রা ৩৫ ডিগ্রী সেলসিয়াসের বেশী হওয়া আবার গাছের পক্ষে ক্ষতিকর তখন বাষ্পীভবনের মাধ্যমে ঠান্ডা করার (evaporative-cooling) বিভিন্ন প্রযুক্তির (যেমন fan pad cooling, high pressure mist system, low pressure mist system) ও অবাধ বায়ু প্রবাহের (ventilation) ব্যবস্থার মাধ্যমে পলিথিনের ছাউনির ভিতর ঠান্ডা করার ব্যবস্থা করা হয়। এই প্রযুক্তির মূলনীতি হলো ভিতরে অতি সুক্ষ্ম জলের কনার পাতলা কুয়াশা (mist) তৈরী করে তাকে বাষ্পিভূত হতে দেওয়া। বাষ্পভবনের মাধ্যমে লীনতাপ শোষিত হয়ে পলিথিনের ছাউনির ভিতরের তাপমাত্রা অনেক কমিয়ে দেয়। এইভাবে ভিতরের তাপমাত্রা অনেক কমিয়ে দেওয়া যায়। এইভাবে ভিতরের তাপমাত্রা কমে যাওয়ার দ্রুততা নির্ভর করে বাইরের বাতাসের আপেক্ষিক আর্দ্রতা ও ভিতরে অবাধ বায়ু প্রবাহের ব্যবস্থার উপর। পলিথিন ছাউনির নীচে ছায়াজালিকা (shade net) দিয়ে ছায়ার ব্যবস্থা করেও ভিতরের তাপমাত্রা কিছুটা কমানো যায়। এছাড়া পলিহাউসের বাইরে জলের ধারা সিঞ্চনের মাধ্যমেও ভিতরের তাপমাত্রা কমিয়ে দেওয়া যায়।

৫) সুক্ষ্ম-নির্দেশী যন্ত্রপাতির মাধ্যমে জল ও সেচের জলের সাথে উদ্ভিদ খাদ্যের যোগান নিয়ন্ত্রিত সব্জি উৎপাদন পদ্ধতির ব্যবস্থাপনা (precision farming)। ফোঁটা ফোঁটা করে জল দেওয়া (drip irrigation) ও সেচের জলের সাথে গাছের চাহিদা অনুযায়ী উদ্ভিদ খাদ্য যোগান দেওয়ার পদ্ধতি (fertigation)-র মাধ্যমে গাছের বৃদ্ধি আশানুরূপভাবে নিয়ন্ত্রণ করে উৎপাদনের খরচ পরিপূর্ণভাবে সদ্ব্যবহার করে ফলনের সর্বোচ্চ লক্ষ্যে পৌছানো যায়।এই ব্যবস্থায় প্রতিনিয়ত পাতার কলায় (tissue) কতটা উদ্ভিদখাদ্য উপাদান আছে তা পরীক্ষা করার ব্যবস্থা (leaf tissue nutrient analysis) থাকতে হবে।এটি অত্যন্ত আধুনিক কৃষি ব্যবস্থাপনার প্রতিফলন যেখানে পরীক্ষাগারের সাথে উৎপাদনক্ষেত্রের সরাসরি যোগাযোগ বিদ্যমান।

৬) ভারতবর্ষের মতো গ্রীষ্মমন্ডলীর আবহাওয়ায় প্রবল বৃষ্টির হাত থেকে গাছকে আড়াল করে তার বৃদ্ধি ও ফলন সুনিশ্চিত করা।

৭) পলিথিন ছাউনির ভিতর গাছের শ্বসন প্রক্রিয়ার উদ্ভুত কার্বনডাই অক্সাইড (CO_2)-এর পরিমান বাইরের খোলা হাওয়ার তুলনায় কিছুটা বেশীই থাকে।এই বর্ধিত কার্বন ডাই অক্সাইড গ্যাস পরিবর্তিতে সালোকসংশ্লেষের কার্যক্ষমতা বৃদ্ধি করে অধিক ফলনের সহায়ক হয়। খুব বেশীমাত্রায় কার্বন ডাই অক্সাইড আবার ক্ষতিকর তাই একে বার করে দেবার জন্য উপযুক্ত ও অবাধ বায়ু প্রবাহের ব্যবস্থা থাকা (ventilation) জরুরী।

ঐতিহাসিক প্রেক্ষাপট ঃ

এই “গ্রীন হাউস” প্রযুক্তির ব্যবহার ইউরোপের বিভিন্ন দেশে শুরু হয়েছিল কয়েক শতাব্দী আগে থেকে ১৭০০ খ্রীষ্টাব্দের প্রথম দিকে। একেবারে প্রথম দিকে মাটিতে গর্ত খুঁড়ে তার উপর প্রায় স্বচ্ছ, পাতলা অভ্রের চাদর ঢাকা দিয়ে শীতকালে কিছু শস্য উৎপাদনের চেষ্টা করা হতো। তারপর এল উপরে কাঁচ দেওয়া পাথরের দেওয়ালের কাঠামোর “গ্রীন হাউস”। ১৭০০ খ্রীষ্টাব্দে এর ভিতর কমলালেবুর চাষ জনপ্রিয় ছিল। গ্রীন হাউসের ভিতর বাণিজ্যিক ভিত্তিতে সব্জি, ফুল ও অন্যান্য সৌন্দর্যবর্ধক গাছপালার চাষ আবাদ শুরু হয় ১৮০০ খ্রীষ্টাব্দে। ১৯০০ খ্রীষ্টাব্দে থেকেই ইউরোপে বিভিন্ন কলাকৌশল সম্মিলিত (design) কাঁচের ঘরের (glass house) ব্যাপক প্রচলন হয়েছিল। “গ্রীন হাউস” প্রযুক্তিতে এক অত্যন্ত গুরুত্বপূর্ণ সাফল্য ও মোড় এল প্লাস্টিক প্রযুক্তির হাত ধরে। পলিইথিলিন পলিমার (polyethylene polymer) যৌগ (পলিমার হলো এক বৃহৎ অনুযুক্ত যৌগ যা গঠিত হয় অনেকগুলি ছোট অনুকে একাদিক্রমে সংযুক্ত করে) প্রথম উৎপাদিত হলো ১৯৩০ খ্রীষ্টাব্দে এবং পলিথিনের চাদর

(sheet), পাইপ, স্প্রিংকলার (spriknler) সেচ বা ফোয়ারা সেচ ও ড্রিপ (drip) বা ফোঁটা সেচের সামগ্রী ইত্যাদি কৃষিতে ব্যবহৃত বহু সামগ্রী তৈরী হলো ১৯৫০-এর দশকে। এরপর থেকেই কাঁচের তৈরী গ্রীন হাউসের পরিবর্তে পলিথিনের চাদরে ঢাকা ছাউনি তৈরী হতে শুরু হলো ব্যাপকভাবে। এরপর আরও নতুন ধরনের সস্তা ও টেকসই প্লাস্টিক তৈরী হলো যেমন পলিভিনাইল ক্লোরাইড (polyvinyl chloride), পলিপ্রপিলিন (polypropylene) এবং পলিএস্টার (polyester)। এখন সারা বিশ্বের ৯০ শতাংশ গ্রীন হাউসই তৈরী হয় অতি বেগুনী রশ্মি সুস্থিত (ultraviolet ray stabilized) পলিথিনের চাদর দিয়ে।

ভারতে গ্রীনহাউস প্রযুক্তির ব্যবহার ঃ

ভারতে গ্রীন হাউস প্রযুক্তি “ইন্দো আমেরিকান হাইব্রিড সিড কোম্পানী” নামক এক সংকর বীজ উৎপাদনকারী কোম্পানী প্রথম ব্যবহার করে ১৯৬৫ সালে ফুলের সংকর বীজ ও ফুল উৎপাদনের জন্য। ওই ৬০-এর দশকের প্রথম দিকেই ভারত সরকারের অধীনস্থ ডিফেন্স রিসার্চ অ্যান্ড ডেভেলপমেন্ট অরগানাইজেসন (Defence Research and Developement Organization, DRDO)-এর অন্তর্গত কৃষি সম্বন্ধিয় শাখা (Field Research Laboratory) লেহ্‌তে প্রথম গ্রীনহাউস প্রযুক্তির মাধ্যমে সব্জি চাষ সংক্রান্ত গবেষণা শুরু করে। আমাদের দেশে পলিথিনের ছাউনির মাধ্যমে “গ্রীণ হাউস” প্রযুক্তির ব্যবহার ও সে সংক্রান্ত গবেষণায় দ্রুততা আসে ১৯৮০-র দশকে যখন ইন্ডিয়ান পেট্রোকেমিক্যাল কোম্পানী লিমিটেড (Indian Petrochemical Company Limited) আমাদের দেশে কম ঘনত্বের পলিথিন (low density polyethylene, L.P.D.E.) -এর চাদর (sheet) বিক্রির ব্যবস্থা শুরু করে। এই সংক্রান্ত গবেষণা D.R.D.O. প্রথম শুরু করে লেহ্‌তে, আগেই বলা হয়েছে। আজ সেখানে ছোট ও মাঝারি মিলিয়ে প্রায় ২০০০-র মতো পলিথিনের ছাউনির ভিতর সব্জি উৎপাদিত হচ্ছে। DRDO-ই প্রথম এই অঞ্চলে লম্বা পরিখা (trench) কেটে মাটির তলায় গ্রীন হাউসের প্রচলন শুরু করে।

আমাদের দেশে কৃষিতে প্লাষ্টিকের ব্যবহার বাড়াবার প্রয়োজনে রাসায়নিক ও পেট্রো রাসায়নিক মন্ত্রক (Ministry of Chemicals and Petrochemicals) -এর অধীনে ন্যাশনাল কমিটি অন দি ইউজ অফ প্লাষ্টিকস্ ইন এগ্রিকালচার (National Committee on the Use of Plastics in Agriculture, NCPA) গঠিত হয় ১৯৮১ সালে, তারপর ১৯৯৩ সালে এটিকে কৃষি মন্ত্রকের অধিনস্থ উদ্যানবিজ্ঞান শাখার সাথে যুক্ত করে দেওয়া হয়। আজ N.C.P.A. -এর অধীনে কৃষি বিশ্ববিদ্যালয় ও অন্যান্য প্রতিষ্ঠানে অবস্থিত ২২টি প্লাস্টিকালচার ডেভেলপমেন্ট সেন্টার (Plasticulture Development Centre, PDC) আছে যেখানে কৃষিতে “গ্রীন হাউস” প্রযুক্তি সমেত প্লাস্টিকের অন্যান্য ব্যবহার সংক্রান্ত গবেষণার কাজ হয়। আমাদের রাজ্যের PDC টি খড়কপুর আই. আই. টি.র কৃষিবিজ্ঞান শাখার অবস্থিত। তবে এই প্লাষ্টিকালচার ডেভেলপমেন্ট সেন্টারের বিভিন্ন শাখা কৃষি বিশ্ববিদ্যালয় ও কৃষিবিজ্ঞান কেন্দ্রে থাকা খুবই জরুরী।

ভারতে সব্জি উৎপাদনে পলিথিন ছাউনির ব্যবহার ঃ

ভারতে “গ্রীণ হাউস” প্রযুক্তির ব্যবহার এখনও প্রায় নগন্য। কিছু উচ্চ প্রযুক্তির গ্রীণ হাউসে যেখানে অভ্যন্তরস্থ জলবায়ু পরিবর্তনের ব্যবস্থা আছে সেখানে রঙিন ক্যাপসিকাম (লাল, হলুদ, বেগুনী) ও ক্যাপসিকামের সংকর বীজ উৎপাদিত হচ্ছে, যদিও তার সংখ্যা খুবই কম। পশ্চিমবঙ্গে এইরকম কয়েকটি “গ্রীণ হাউস” রঙিন ক্যাপসিকাম বাণিজ্যিকভাবে উৎপাদন করার প্রচেষ্টা হচ্ছে। গ্রীণ হাউসে বাণিজ্যিক ভিত্তিকে সব্জির চারা তৈরী করা হচ্ছে। পাঞ্জাব, হরিয়ানা ও উত্তরপ্রদেশে কম মূল্যের পলিথিন সুড়ঙ্গের

(poly tunnel) ভিতর জলদি বাজারে আনার জন্য শস্য, খরমুজ ও সামার স্কোয়ার (কাঁচা কুমড়োর মত) চাষ হচ্ছে বেশ কয়েক বছর হলো। পশ্চিমবঙ্গের কৃষকেরা সব্জির চারা উৎপাদনের প্লাস্টিকের ব্যবহার সম্বন্ধে সম্যক্ অবহিত কিন্তু একে ব্যবহার সম্বন্ধে সম্যক্ অবহিত কিন্তু একে ব্যবহার করে সব্জি উৎপাদনের প্রচেষ্টা পায় নেই বললেই চলে।

উচ্চ ও মাঝারি মূল্যের গ্রীণ হাউস তৈরীর জন্য বিবেচনাধীন কয়েকটি বিষয় ঃ

(১) **সব্জি শস্য নির্বাচন ঃ** এমনিতে সমস্ত সব্জিরই ফলন ভালো হয় যদি পলিথিন ছাউনির অভ্যন্তরস্থ জলবায়ুর সুবিধাজনক পরিবর্তন ঘটানো যায়। তথাপি উচ্চমূল্যের কিছু সব্জি যেমন শীতকালে উৎপাদিত শসা ও ট্যাড়স; বর্ষার শেষ থেকে বসন্তকাল পর্যন্ত রঙিন ক্যাপসিকাম; বর্ষায় জলদি ফুলকপি; শরৎ থেকে বসন্তকাল পর্যন্ত উচ্চ গুনমানের লেটুস, চাইনিজ বাঁধাকপি, পাকচোই; শীতের শেষ থেকে গরমের প্রথম পর্যন্ত টম্যাটো ইত্যাদি উৎপাদন করাই বাঞ্ছনীয়, কারণ এই সব্জিগুলির বাজার দর, ফসলের উৎপাদনের সময় ও গুনমানের উপর খুবই নির্ভরশীল।

(২) **উপযুক্ত উচ্চফলনশীল বা সংকর জাত নির্বাচন ঃ** নির্দিষ্ট বাজারের চাহিদার কথা মাথায় রেখেই উচ্চফলনশীল বা সংকর জাত নির্বাচন করা জরুরী।

(৩) **উচ্চমানের জলের যোগান ঃ** সেচের জলের মানের উপর গ্রীন হাউসের শস্যের বৃদ্ধি ও ফলন খুবই নির্ভরশীল। নদী, নালা ও পুকুরের জলে বিভিন্ন রোগজীবাণু ও গাছের কৃমি বাহিত হয়। একটু গভীর স্যালো টিউব ওয়েলের জলে সমস্যা হয় না। এই জলের সাথে উদ্ভিদ খাদ্য মিশিয়ে ফোঁটা ফোঁটা করে গাছের গোড়ায় দেবার আদে অবশ্যই জল পরীক্ষা করে নিতে হবে যাতে জলের অম্লত্ব/ক্ষারত্ব, দ্রবীভূত অবস্থায় লবন, বাই-কার্বোনেট, লোহা, গন্ধক, ক্যালসিয়াম ও ম্যাগানেসিয়ামের পরিমাণ জানা যায়।

(৪) **নীরোগ চারা তৈরী ঃ** প্লাস্টিকের নীচু টানেলের ভিতর ছোট ছোট পটে জীবাণুমুক্ত অবস্থায় সুস্থ, বলিষ্ঠ ও নীরোগ চারা তৈরীর মাধ্যমেই "গ্রীণ হাউস" প্রযুক্তির সুফল পরিপূর্ণভাবে নেওয়া যায়।

(৫) **ভালো যাতায়াত ব্যবস্থা ও নির্দিষ্ট বাজার ঃ** শহরে সাথে ভালো যোগাযোগ ব্যবস্থা আছে এমন জায়গায় একসাথে অনেকগুলি গ্রীণ হাউস থাকাই বাঞ্ছনীয় তাহলে নির্দিষ্ট পরিমাণ চাহিদা মেটাবার জন্যে উপযুক্ত উৎপাদন পাওয়া যায়।

(৬) **দক্ষ শ্রমিক ঃ** খোলা জায়গায় ও গ্রীণ হাউসের ভিতর সব্জির উৎপাদন পদ্ধতির মধ্যে অনেক ফারাক আছে। গ্রীণ হাউসের প্রযুক্তি রূপায়নের প্রায়োগিক দক্ষতাব ভূমিকা অপরিসীম। বিধানচন্দ্র কৃষি বিশ্ববিদ্যালয় গ্রীণ হাউস প্রযুক্তি সংক্রান্ত সমস্ত বিষয়ে প্রশিক্ষনে অগ্রণী ভূমিকা নিতে পারে।

(৭) **নিয়ন্ত্রিত সেচ ঃ** পলিথিনের ছাউনির ভিতর অভ্যন্তরস্থ জলবায়ুর সুবিধাজনক পরিবর্তন ঘটিয়ে উৎপাদন ও উৎপাদিত ফসলের গুনমানের সর্বোচ্চ লক্ষে পৌছাবার লক্ষে নিয়ন্ত্রিত সেচ ও উদ্ভিদখাদ্যের যোগান দুই-ই বিশেষভাবে জরুরী। অনিয়ন্ত্রিত সেচ শুধু গাছের পরিকল্পিত বৃদ্ধিরই ব্যাঘাত ঘটায় না অহেতুক অনেক রোগজনিত সমস্যা ডেকে আনে। গ্রীণ হাউসের ভিতর সাধারণভাবে ফোঁটা সেচ (drip irrigation) পদ্ধতিতে সেচ দেওয়া হয়। এছাড়া ঝরনা সেচ (sprinkler irrigation) দেবারও প্রচলন আছে, তবে পশ্চিমবঙ্গের আর্দ্র আবহাওয়ায় এই সেচ পদ্ধতি গাছের পাতার ছত্রাক ও ব্যাকটেরিয়াজনিত রোগের প্রাদুর্ভাব বাড়াতে পারে।

(৮) **নিয়ন্ত্রিত উদ্ভিদ খাদ্যের যোগান ঃ** যে কোনো গাছের কার্য সম্পাদন (performance) যেমন ফলন দেবার ক্ষমতা (yielding ability) নির্ভর করে সেই সব্জি শস্যের বিশেষ উন্নত জাত (ভ্যারাইটি) বা সংকরজা (হাইব্রিড) -এর নির্দিষ্ট জেনেটিক বা বংশগতি বিষয়ক গঠনের উপর আর কোন্ পরিবেশে তাকে লালন পালন করা হচ্ছে তার উপর। গ্রীন হাউস প্রযুক্তি রূপায়নে সেই পরিবেশরই সুবিধাজনক পরিবর্তন ঘটিয়ে সেই নির্দিষ্ট উন্নত বা সংকর জাতটিকে সুষ্ঠভাবে কার্য সম্পাদন করার জন্য ক্ষমতার শীর্ষে পৌছতে সাহায্য করা হয়। উদ্ভিদ খাদ্যের যোগান পরিবেশেরই একটি দিক, এবং এর নিয়ন্ত্রিত অথচ সুষ্ঠু যোগানের উপর ফলন ও ফসলের গুনমান বহুলাংশে নির্ভরশীল। সাধারণত ফোঁটা সেচ ব্যবস্থার সাথেই তরল অবস্থায় উদ্ভিদ খাদ্যের যোগান দেওয়াকে একসাথে মিলিয়ে দেওয়া হয়। সুক্ষ্ম নির্দেশী যন্ত্রপাতির মাধ্যমে জল ও উদ্ভিদ খাদ্যের যোগান দেবার পদ্ধতিকে ফার্টিগেশন বলে। আগেই উল্লেখিত হয়েছে যে প্রতিনিয়ত পাতার কলায় (tissue) কতটা উদ্ভিদ খাদ্য উপাদান আছে তা পরীক্ষাগারে পরীক্ষা করেই এইভাবে উদ্ভিদখাদ্যের যোগানের ব্যবস্থা করতে হয়।

গ্রীণ হাউসের সব্জি শস্যে উদ্ভিদখাদ্যে যোগানের মোটামুটি কতটা প্রয়োজন হয় তার একটা হিসাব দেওয়া হল। সব্জি বিশেষে এর কিছুটা তারতম্য তো হবেই।

রাসায়নিক	চারা লাগানো থেকে প্রথম ফল আসা পর্যন্ত (গ্রাম প্রতি ১০০ লিটার জলে)	প্রথম ফল আসা থেকে শেষ পর্যন্ত (গ্রাম প্রতি ১০০ লিটার জলে)
ম্যাগনেসিয়াম সালফেট	৫০	৫০
মনোপটাশিয়াম ফসফেট	২৭	২৭
পটাশিয়াম নাইট্রেট	২০	২০
ক্যালসিয়াম নাইট্রেট	৫০	৬৮
লোহা (এফ.ই. ৩৩০)	২.৫	২.৫
অনুখাদ্যের স্টক দ্রবণ (পরে বলা হয়েছে)	১৫ মিলিমিটার	১৫ মিলিমিটার

১০০ লিটার জলে উপরোক্ত রাসায়নিক গুলে ফোঁটা সেচের মাধ্যমে প্রায় রোজই গাছের গোড়ায় উদ্ভিদখাদ্য যোগান দিতে হবে।

অনুখাদ্যের স্টক দ্রবণ তৈরী করা

রাসায়নিক	পরিমাণ (গ্রাম)
বোরিক অ্যাসিড	৭.৫০
ম্যাঙ্গানাস ক্লোরাইড	৬.৭৫
কিউপ্রিক ক্লোরাইড	০.৩৭
মলিবডেনাম ট্রাইঅক্সাইড	০.১৫
জিঙ্ক সালফেট	১.১৮
মোট	**১৫.৯৫ গ্রাম**

এই ১৫.৯৫ গ্রাম অনুখাদ্য সমৃদ্ধ রাসায়নিকগুলি ৪৫০ মিলিলিটার জলে গুলে (দরকার মত গরম করে) অনুখাদ্যের স্টক দ্রবণ বানানো হয়। এই স্টক দ্রবণ থেকে ১৫ মিলি. লিটার নিয়ে অন্যান্য উদ্ভিদ খাদ্যসহ ১০০ লিটার জলে গুলে গাছের শিকড় অঞ্চলে ফোঁটা ফোঁটা করে যোগান দিতে হয়।

সুস্থ ও সবল গাছের পাতায় নিম্নোক্ত পরিমাণ বিভিন্ন উদ্ভিদখাদ্য থাকা বাঞ্ছনীয়

উদ্ভিদ খাদ্য	সব্জি শস্য						
	খরমুজ	শশা	বেগুন	ক্যাপসিকাম	সামাব স্কোয়াশ	টম্যাটো	তরমুজ
শতাংশ হিসাবে							
নাইট্রোজেন	২.০০-৪.০০	৫ ০০-৬.০০	৪.০০-৬.০০	৫.০০-৫.৫০	৪.০০-৬.০০	৩.৫০-৫.০০	২ ৫০-৪.৫০
ফসফরাস	০.২৫-০.৪০	০.৩০-১.০০	০.৩০-১.০০	০ ৩৫-০.৪৫	০.২৫-১.০০	০.৩৫-০.৪৫	০.২৫-০.৭৫
পটাশ	১.৮০-৪.০০	৪.০-৫.০০	৬.৫০-৫.০০	৪.৫০-৬.০০	৩.০০-৫.০০	৩.৫০-৫.০০	২.২৫-৩.৫০
ক্যালসিয়াম	১.৮০-৭.০০	১.২০-৩.৫০	১.০০-২.৫০	১.০০-১.৫০	১.০০-২.৫০	১.০০-১.৫০	১.১০-১.৫০
ম্যাগনেসিয়াম	০.৫০-১.৫০	০.৩০-১.০০	০.৩০-১.০০	০.৩০-০.৪০	০.৩০-১.০০	০.৩০-১.০০	০.২৫-০.৮০
গন্ধক	০.২০-০.৬০	০.২০-০.৪০	০.২০-০.৪০	০.১৫-০.৪০	০.২০-০.৭৫	০.২০-০ ৪০	০.২০-০.৭৫
পি.পি.এম* হিসাবে							
বোরণ	২০-৮০	২৫-৭৫	২৫-৭৫	২৫-৯৫	২৫-৭৫	৩০-১০০	৩০-৭৫
লোহা	৪০-২০০	৫০-২০০	৫০-২০০	৪০-২০০	৪০-২০০	৪৫-২০০	৪০-২০০
ম্যাঙ্গানিজ	২০-২০০	২৫-২০০	২৫-২০০	২০-২০০	২৫-২০০	২০-২০০	২৫-২০০
দস্তা	২০-৬০	২০-৭৫	২০-৭৫	২০-৬০	২০-৭৫	২০-৬০	২০-৭৫
তামা	৪-২৫	৫-৩৫	৫-৩৫	৫-৩৫	৫-৩৫	৫-৩৫	৪-১৫

*পি.পি.এম. - মিলিগ্রাম প্রতি লিটারে।

(৯) **রোগ ও কীটশত্রু দমন ব্যবস্থা** ঃ পলিথিন ছাউনির ভিতর গাছের রোগ. কীটশত্রু ও মাটির কৃমি দমনের জন্য কতকগুলি অবশ্য পালনীয় কর্তব্যগুলি বলা হয়েছে।

(ক) নতুন ফসল লাগানোর আগে পলিথিন ছাউনির ভিতর অবশ্যই ভালো করে শোধন ও জীবাণুমুক্ত করে নিতে হবে।

(খ) গাছের সমস্ত পড়ে থাকা অংশ বাইরে নিয়ে গিয়ে পুড়িয়ে ফেলতে হবে।

(গ) গাছে হাত দেওয়ার আগে ও পরে অবশ্যই সাবান দিয়ে হাত কচলে ধুয়ে নিতে হবে।

(ঘ) বাইরে থেকে কোনো মাটি ভিতরে আনা চলবে না।

(ঙ) গ্রীণ হাউসের ভিতর ধূমপান বা নস্যি নেওয়া একেবারেই নয় কারণ এতে তামাকে থাকা ভাইরাস গাছে সংক্রামিত হবার সম্ভাবনা থাকে।

(চ) সমস্ত কৃষি যন্ত্রপাতি কাজ হয়ে যাবার পর কার্বলিক অ্যাসিড সাবান বা লাইজল দিয়ে ধুয়ে রাখতে হবে।

(ছ) গ্রীণ হাউসের ভিতর বাইরে থেকে যত কম লোক আসে ততই ভাল।

সুরক্ষিত উৎপাদন ব্যবস্থা কেন ?ঃ

(১) শস্যকে কম ও বেশী তাপমাত্রা, বেশী বৃষ্টি ও বাতাসের বেগ থেকে রক্ষা করা।
(২) পলিথিনের ছাউনির অভ্যন্তরস্থ জলবায়ুর সুবিধাজনক পরিবর্তন ঘটিয়ে গাছের বৃদ্ধি, বিকাশ, ফলন ও ফসলের গুণমান বাড়ানো।
(৩) গাছে রোগ ও পোকার আক্রমণ কমানো।
(৪) অসময়ে বা বেশী সময় ধরে ফসলের উৎপাদন করা।
(৫) সুক্ষ নির্দেশী প্রযুক্তির (Precision farming technology) ব্যবহার করা।
(৬) জলদি ফলন ও বেশীদিন ধরে উৎপাদন ধরে রাখা।
(৭) বাইরের প্রতিকুল আবহাওয়াতেও এই ছাউনির ভিতর সফলভাবে শস্য উৎপাদন করা।
(৮) ঢালু জমিতেও সফলভাবে সবজি উৎপাদন করা।

সুরক্ষিত উৎপাদন ব্যবস্থার বহুমুখী ব্যবহার ঃ

(১) উচ্চ গুণমানের বিভিন্ন সবজি উৎপাদন।
(২) অসময়ে সবজি উৎপাদন।
(৩) রপ্তানীযোগ্য সবজি ও ফুল উৎপাদন।
(৪) উচ্চ গুণমানের ও নিরোগ চারা তৈরী করা।
(৫) টিস্যু কালচারের চারাসমূহ পোক্ত করা।
(৬) কোন কোন বিশেষ সবজির সাধারণ ও সংকর বীজ উৎপাদন করা।

সুক্ষ নির্দেশী প্রযুক্তির প্রয়োজনীয়তা ঃ

(১) গ্রামাঞ্চল কৃষি শ্রমিকের অপ্রতুলতা।
(২) কৃষিতে খরচ বেড়ে যাওয়া।
(৩) কৃষি থেকে ধারাবাহিকভাবে লাভ কমে যাওয়া।
(৪) একসাথে বেশী উৎপাদনের জন্য বাজারে দাম না পাওয়া।
(৫) সেচের জলের অপ্রতুলতা।
(৬) ঋনের ফাঁদে জড়িয়ে পড়া।
(৭) কৃষি প্রযুক্তি ও বিপননে তথ্য সম্প্রসারণের অভাব।

সুক্ষ নির্দেশী উৎপাদন ব্যবস্থাপনার সুফল ঃ

(১) এই ব্যবস্থায় শুধু ফসলের উৎপাদন বাড়ে না, কৃষকের আত্মবিশ্বাসও বাড়ে।
(২) উচ্চ গুনমানের সবজির উৎপাদন।
(৩) বেশীদিন ধরে ফলন ধরে রেখে বাজার দরে প্রভাব বিস্তার করা।
(৪) বিভিন্ন কৃষি উপকরণের কম ব্যবহার।
(৫) উদ্ভিদখাদ্য ও সেচের জলের ব্যবহারের কার্যক্ষমতা বাড়ানো।
(৬) উৎপাদন খরচ কমানো।
(৭) ফোঁটা সেচ ও জলের সাথে উদ্ভিদখাদ্য দেওয়ার মাধ্যমে খরচ কমানো।
(৮) পণ্যের বাজার সম্পর্কে কৃষকের সম্যক্ ধরানো জন্মানো।
(৯) মাটির উপকারী জীবাণুর সংখ্যা বাড়ানো।

বিভিন্ন সুরক্ষিত উৎপাদন ব্যবস্থা ঃ

— গ্রীণ হাউস বা পলি হাউস (poly house)
— ছায়া প্রদানকারী ছাউনি (shade net house)
— মশারী জালের ছাউনি (net house)
— প্লাস্টিকের সুড়ঙ্গ (poly tunnel)
— মাটির ওপরকার আচ্ছাদন (mulching)।

বিভিন্ন গঠনশৈলীর পলিহাউস ঃ

- রাউন্ড টপ
- হাট বা কুটিরের মত
- লিন-টু
- ওয়াক ইন টানেল
- সেলটার
- মাল্টি স্প্যান।

(১) *কম খরচার পলি হাউস ঃ* সাধারন পলিথিনের ছাউনি। কোন নিয়ন্ত্রন ব্যবস্থা নেই। বিদ্যুতের প্রয়োজন নেই। পাইপ দিয়ে নিয়ন্ত্রিত সেচ ব্যবস্থা। ভিতরে তাপমাত্রা ৬-৮° সেন্টিগ্রেট পর্যন্ত বেড়ে যায়। হাওয়া চলাচল ব্যবস্থার মাধ্যমে তাপমাত্রা নিয়ন্ত্রন করা হয়। ভিতরে সূর্যালোকের ৩০-৪০ শতাংশ কম পৌছয়।

(২) *বেশী খরচার পলি হাউস ঃ* বিভিন্ন নিয়ন্ত্রন ব্যবস্থা সম্বলিত জটিল গঠন শৈলির পলিহাউস। এই ছাউনির মধ্যে আছে ফোঁটা সেচ (drip irrigation), নির্গমন পাখা (exhaust fan), কুয়াশা তৈরী (misting) ও ঘর ঠান্ডা রাখার ব্যবস্থা (cooling system)। বাইরে আছে পাম্প ও জলাধারের ব্যবস্থা। খরচা ও উৎপাদিত ফসলের বিপনন ব্যবস্থা বুঝেই বিনিয়োগ প্রয়োজন।

(৩) *মাঝারি খরচের পলিহাউস ঃ* মাটির উপর ফোঁটা সেচ ব্যবস্থা (surface drip), কুয়াশা তৈরী ব্যবস্থা (misting), ৫০ শতাংশছায়া জালিকার ব্যবহার (50% shade net)। উপরের ও পাশে বাতাস চলাচলের পথে পোকা আটকানোর জন্য সুক্ষ জালের ব্যবহার। বাইরে আছে পাম্প ও জলাধারের ব্যবস্থা।

মাঝারী খরচার পলিহাউসে রঙিন ক্যাপসিকাম উৎপাদন পদ্ধতি ঃ

জাত/শংকর জাত

হলুদ ঃ স্বর্ণ, সি-৪, ভ্রারকো, টেনাটো।
লাল ঃ নাতাশা, অদিতি, বেবিবেল, ক্রুসেডার, ফ্যাসিনাটো।
বেগুনী ঃ নিকিতা।

চারা তৈরী

- থাইরাম (৩ গ্রাম প্রতি কেজি) ও ব্যাভিস্টিন (২ গ্রাম প্রতি কেজি) দিয়ে বীজ শোধন।
- মশারীর ভিতর চারা উৎপাদন।
- মাটির জীবাণুমুক্ত করা ও ফিউরাডন ৫ গ্রাম প্রতি বর্গমিটারে প্রয়োগ।
- চারায় প্রথমে জল না দিয়ে ব্লাইটক্স গোলা জল (৩ গ্রাম প্রতি লিটার) দেওয়া।

- ব্লাইটক্স গোলা জল দেবার ৭ দিন পর প্রথম স্প্রে ম্যানকোজেব ২.৫ গ্রাম + ব্যাভিষ্টিন ১ গ্রাম প্রতি লিটারে।
- দ্বিতীয় স্প্রে ইমিডাক্লোপ্রিড ১ মিলি প্রতি ৩ লিটারে।
- তৃত্বীয় স্প্রে আবার ইমিডাক্লোপ্রিড ১ মিলি প্রতি ৩ লিটারে, চারা তোলার ২-৩ দিন আগে।

চারা লাগানোর সময়

১৫ আগষ্ট, ১৫ সেপ্টেম্বর, ১৫ অক্টোবর, ১৫ ডিসেম্বর।

চারা লাগানোর পদ্ধতি

১.২ মিটার চওড়া ও ২৫ সেমি উঁচু বেড়ে দুসারি; তারপর ৩০ সেমি চওড়া নালা।

চারার দূরত্ব

৬০×৫০ সেমি।

উদ্ভিদ খাদ্য প্রয়োগ

- হেক্টর প্রতি ২৫০ঃ১০০ঃ২৫০ কেজি হারে নাইট্রোজেন, ফসফরাস ও পটাশ।
- চারা লাগানোর সময় গাছ প্রতি ১০ গ্রাম ইউরিয়া + ২৫ গ্রাম সিংগল সুপার ফসফেট + ২০ গ্রাম মিউরিয়েট অফ পটাশ প্রদান।
- প্রথম চাপান চারা লাগানোর ৩০-৩৫ দিন পর। গাছ প্রতি ১০ গ্রাম ইউরিয়া + ২৫ গ্রাম সিংগল সুপার ফসফেট + ২০ গ্রাম মিউরিয়েট অফ পটাশ।
- দ্বিতীয় চাপান ৮০-৯০ দিন পর। গাছ প্রতি ১০ গ্রাম ইউরিয়া।
- তিনবার অনুখাদ্য মিশ্রনের স্প্রে, ৩৫, ৪৫ ও ৫৫ দিন পর পর।
- সমস্ত স্রের সাথে আঠা ব্যবহার অবশ্যই প্রয়োজন।

শস্য সুরক্ষা

- চারা লাগানোর পর গোড়ায় মেটালক্সিল + ম্যানকোজের ২.৫ গ্রাম প্রতি লিটার জলে গুলে অল্প দেওয়া।
- সাতদিন পর ইমিডাক্লেপ্রিড ১ মিলি প্রতি ৩ লিটার জলে স্প্রে; তার তিনদিন পর ফিপ্রোনিল (রিজেন্ট) ১ মিলি প্রতি লিটার জলে স্প্রে।
- এর ৮-১০ দিন পর প্রথমে ডাইকোফল ৩ মিলি প্রতি লিটারে অথবা ডায়াফেনথিউরন (পেগাসাস) ২ মিলি প্রতি ৪ লিটার জলে স্প্রে; তার ৩ দিন পর ফিপ্রোনিল (রিজেন্ট) ১ মিলি প্রতি লিটার জলে স্প্রে।
- মাকড় এবং থ্রিপসের আক্রমণ থাকলে এই স্প্রে আরও দুবার করতে হবে।
- ফল ধরার পর মেটালাক্সিল + ম্যানকোজেব অথবা কারবেনডাজিম + ম্যানকোজেব ২.৫ গ্রাম প্রতি লিটার জলে স্প্রে।
- ফল ছিদ্রকারী পোকার আক্রমণ থাকলে ডাইক্লোরভস (নুভাস) ৩ মিলি প্রতি ৪ লিটার জলে স্প্রে।
- স্প্রের সাথে আঠা লাগানো অবশ্যই দরকার।

পলিহাউসে উৎপাদিত রঙিন ক্যাপসিকামে সবচেয়ে মারাত্মক পোকার আক্রমণ

- মাকড়ের আক্রমণে পাতা নীচের দিকে হুকের মত বাঁকা হয় ছোট হয়ে যায়।
- থ্রিপসের আক্রমণে পাতা উপর দিকে বাঁকা হয় এবং ফোস্কা পড়ার মত লাগে। ফলও বাঁকাচোরা হয়।

ক্যাপসিকামে আরও কিছু গুরুত্বপূর্ণ রোগ ও পোকার আক্রমণ

- ফল ছিদ্রকারী হেলিকোভারপা পোকার আক্রমণ।
- কোয়ানোফোরা ছত্রকের আক্রমণে পাতার ঝলসা ও ওপর থেকে মরে যাওয়া।
- ফাইটপথোরা ছত্রাকের আক্রমণে ফল পচা।

৫০০ বর্গমিটার মাঝারি খরচের পলিহাউসে রঙিন ক্যাপসিকামের উৎপাদন ঃ

বেডের মাপ

- দরজা বরাবর ১ মিটার ও পাশ থেকে ৫০ সেমি ছেড়ে ৮.৫ × ১.২ মিটার বেড হয়।

মোট বেডের সংখ্যা

- ৩৩ (চারবার চারা লাগানোর হিসাবে প্রতিবারে ৮টি করে বেড ব্যবহার)।

বেডে ও পলিহাউসে গাছের সংখ্যা

- বেড প্রতি ৩২ টি, প্রতিবার লাগানোর সময় ৮ টি বেডে ২৫৬ টি এবং পলিহাউসে মোট ১০৫৬ টি গাছ।

কার্যকরী গাছের সংখ্যা

- প্রতিবার লাগানোর হিসাবে ২৪২ টি ও মোট ১০০০ টি।

গড় ফল উৎপাদন

- প্রতিবার লাগানোর হিসাবে ৩৫০ কেজি ও মোট উৎপাদন ১৪০০ কেজি (গাছ প্রতি গড়ে ১.৫ কেজি হিসাবে)।

৫০০ বর্গমিটার মাঝারি খরচের পলিহাউসে রঙিন ক্যাপসিকাম উৎপাদন খরচ ও লাভ

তালিকাভুক্ত বিষয়	খরচ
১) পলিহাউস পরিষ্কার ও জীবাণুমুক্ত করা	৫০০০.০০
২) ১২০০ টি চারা দাম	৬০০০.০০
৩) ১০০০ কেজি গোবর সার	১০০০.০০
৪) ২৫০ কেজি ভার্মিকম্পোস্ট	১২৫০.০০
৫) সার ও অনুখাদ্য	৫৫০.০০
৬) ফসল সুরক্ষার ঔষধ	৫০০.০০
৭) গাছে ঠেকা দেওয়ার খরচ	৫০০.০০
৮) বিদ্যুতের খরচ (দিনে ১ ঘন্টা হিসাবে)	১৫০০.০০
৯) কৃষি শ্রমিকের খরচ (১০০ জন, দিনে ১৬৭ টাকা হিসাবে)	১৬৭০০.০০
১০) বিবিধ খরচ	২৫০০.০০
মোট খরচ	৩৫,৫০০.০০
গড় উৎপাদন	১৪০০ কেজি
মোট মূল্য (গড়ে ১০০ টাকা কেজি প্রতি হিসাবে	১,৪০,০০০.০০ টাকা
মোট লাভ (ব্যাঙ্কের সুদ না ধরলে)	১,০৪,৫০০,০০ টাকা

কত দিন ধরে উৎপাদন হবে

- ১৫ নভেম্বর থেকে এপ্রিলের শেষ পর্যন্ত।

ফল উৎপাদনের গুরুত্বপূর্ণ ধাপ

- ফুল ফোটার ২৫-৩০ দিন পর রং ধরা শুরু হয়; আরও ১৫-২০ দিন পর ফলে পুরো রং ধরে।

বিপণন ব্যবস্থার মধ্যে কতদিন ফল রাখা যায়

- সাধারণ তাপমাত্রায় ফুল ফোটার ৩০-৩৫ দিন পর থেকে ৫৫-৬০ দিন পর্যন্ত; প্রায় এক মাস। ঠান্ডা করার ব্যবস্থা থাকলে আরও একমাস বেশী পর্যন্ত ফল রাখা যায়।

মোট লাভ

- ব্যাংকের সুদ না ধরলে ১ লক্ষ ৪ হাজার ৫০০ টাকা।

কোন সময় রঙিন ক্যাপসিকাম করা যাবে না

- মে, জুন আর জুলাই মাস।

এই সময়ে পলি হাউসে কি করা দরকার

- পরিষ্কার করা, মাটি জীবাণুমুক্ত করা জমি তৈরী, ফোঁটা সেচ ব্যবস্থা ঠিকঠাক আছে কিনা দেখা, আর জলদি ফুলকপি, বাঁধা কপির চারা করা, ধনে পাতা উৎপাদন করা ইত্যাদি। এতে বাড়তি কিছু আয় করা যাবে।

পলিহাউসে নাবি টম্যাটো উৎপাদন পদ্ধতি ঃ

পলিহাউসে ব্যবস্থাপনা

- মাটির ওপর ফোঁটা সেচ ব্যবস্থা, কুয়াশার ব্যবস্থা, ৫০ শতাংশ ছায়া দেওয়া জাল ব্যবহার।

জাত বা সংকর

- নিধি, অভিমুন্য, হিমসোনা, লক্ষ্মী।

লাগানোর সময়

- ডিসেম্বরের মাঝামাঝি।

ফল উৎপাদনের সময়

- ফেব্রুয়ারীর মাঝামাঝি থেকে এপ্রিলের দ্বিতীয় সপ্তাহ পর্যন্ত।

অল্প খরচের গ্রীনহাউস প্রযুক্তি ঃ

আমাদের দেশে সব্জি উৎপাদনে "গ্রীন হাউস" প্রযুক্তির ব্যবহার খুবই কম তার দুটি প্রধান কারণ হলো ঃ এই প্রযুক্ত খরচসাপেক্ষ, তাই শুধু বেশী দামী সব্জি উৎপাদনই এর ভেতর করা বাণিজ্যিকভাবে সম্ভব আর আমাদের দেশের বিভিন্ন অংশের তুলনাহীন জলবায়ু বৈচিত্র্যের জন্য যে কোনো সব্জি সারা বৎসর কোনো না কোনো জায়গায় উৎপাদিত হয়। এমতাবস্থায় অল্পমূল্যের পলিথিনের ছাউনির প্রচলন হওয়া খুবই জরুরী যার ভিতর কিছুটা অসময়ে বেশ কয়েকটা সব্জি বাণিজ্যিকভাবে করা যায়। অল্পমূল্যের 'গ্রীন হাউস' প্রযুক্তিতে শুধু বাঁশ, কাঠ ও বাঁশের চটা দিয়ে ৯ ফুট উঁচু, ১৫ ফুট চওড়া ও ৫০-৫৫ ফুট কাঠামো করা হয় যার সামনে ও পিছনে দরজার ব্যবস্থা থাকবে। যদি এই ধরনের পলিথিন ছাউনিগুলি শহরতলির কাছাকাছি করা হয় তবে পৌরসভার ট্যাপ কলের লাইনের সাথে একটি সিনটেক্স বা প্যাটন জলের ট্যাঙ্ক জুড়ে দিয়ে তার থেকে জলের লাইন করে নিয়ে যে কোন সময় ছাউনির ভিতরে পলিথিন পাইপ দিয়ে জল দেবার বন্দোবস্ত করা হয়। এটা খুবই উপযোগি কারন পলিথিন ছাউনির ভিতব জলের ব্যবহারে নিয়ন্ত্রণ অত্যন্ত জরুরী।

এই ধরনের অল্প খরচের পলিথিন ছাউনির অভ্যন্তরস্থ জলবায়ুর খুব কমই পরিবর্ত্তন করা সম্ভব। শীতকালে 'গ্রীন হাউস এফেক্টের' জন্য ভিতরের তাপমাত্রা জলবায়ু বিশেষে ৫-৯ ডিগ্রি সেলসিয়াস

বেড়ে যায় যা খুব শীতে টমাটো, ক্যাপসিকাম, শশা, সামার স্কোয়াস ও ট্যাঁড়স উৎপাদনের জন্য খুবই উপযোগি। গ্রীষ্মকালে এর ভিতর তাপমাত্রা খুবই বেড়ে যায়। ভিতরে চট টাঙ্গিয়ে তাতে জল ছিটিয়ে ও ওপরে চট ঢাকা দিয়ে ও ভালো বাতাস চলাচলের ব্যবস্থা করে ভিতরের তাপমাত্রা কিছুটা কমানো যায়। তবুও আমাদের মত আবহাওয়ায় এপ্রিল থেকে জুন মাস পর্যন্ত এর ভিতর প্রায় কোনো কাজই করা যায় না। তখন ভিতরকার মাটি ভালো করে খুঁড়ে গোবর সার বা ভার্মিকম্পোষ্ট মিশিয়ে ভালো করে রোদ খাওয়াতে হবে যাতে মাটিবাহিত জীবানু ও ক্রিমির সংখ্যা কমিয়ে তাদের আক্রমণ প্রতিহিত করা যায়। আমরা হিসাব করে দেখেছি এই ধরনের পলিথিন ছাউনি তৈরীর খরচ প্রতি বর্গমিটারে ২২৮ টাকার মতো। ৫০ ফুট লম্বা, ১৫ ফুট চওড়া ও ৯ ফুট উঁচু একটি পলিথিনের ছাউনির খরচা পড়বে প্রায় ১৫০০০ টাকা। এর মধ্যে ৭০০০-৭৫০০ টাকা শুধু অতি বেগুনী রশ্মি সুস্থিত ২০০ মাইক্রোন পুরু, ২৫ কেজি পলিথিন চাদরের দাম। বাকিটা বাঁশ, বাঁশের চটা, গ্যালভানাইজড্ তার, নাট বল্টু ও মজুরীর খরচ। ঠিকভাবে রাখলে পলিথিনের চাদর তিন বছর পর্যন্ত ভালো থাকে। ভালো করে আলকাতরা মাখিয়ে বাঁশ পুঁতলে কাঠামো ৪-৫ বৎসর পর্যন্ত ভালোই থাকে।

কম খরচের পলি হাউস এবং পলি টানেলের ব্যবহার ঃ

অতি বৃষ্টি থেকে গাছ রক্ষা পাওয়া ও শীতে ভিতরে তাপমাত্রা বেড়ে যাওয়ার জন্য, বছরের প্রায় ৮ মাস (জুলাই থেকে মার্চ পর্যন্ত) এর ভিতর উন্নত গুনমানের সবজি উৎপাদন করা সম্ভব।

- সবুজ ক্যাপসিকাম আগে ও পরে লাগিয়ে অনেকদিন ফলন পাওয়া যায়।
- শীতে ঘন করে ট্যাড়স লাগিয়ে ভাল উৎপাদন পাওয়া যায়।
- খুব তাড়াতাড়ি (সেপ্টেম্বরের শেষ নাগাদ) জলদি ফুলকপির ফলন পাওয়া যায়।
- বসন্ত থেকে বর্ষাকাল পর্যন্ত ধনেপাতা, মেথি শাক ও মুলার চাষ সম্ভব।
- নাবিতে টম্যাটো উৎপাদন করা।
- উন্নত গুনমানের চেরি টম্যাটো, ব্রকোলি, চাইনিজ বাঁধাকপি আর লেটুস উৎপাদন।
- শীতকালে পলিব্যাগে শশা, তরমুজ উচ্ছে ও পেপেঁর চারা তৈরী করা।
- বর্ষায় সবজির উন্নত গুনমানের চারা উৎপাদন।
- টিসু কালচারের চারা পোক্ত করা।

একটি ১৫×৪ মিটার (৬৭.৫ মিটার) কম খরচার পলিহাউস তৈরীর খরচ

সামগ্রী	লম্বা	পরিমাণ	খরচ
৯ সেমি ব্যাসের মোটা বাঁশ	৮০ ফুট	১৫ টি	২০০০.০০
৬ সেমি ব্যাসের মোটা বাঁশ	৩.০ ফুট	২৬ টি	১৪০০.০০
বাঁশের চটা	২০ ফুট	৩০ টি	১৬০০.০০
সবচেয়ে ভালো গুনমানের বিদেশী ২০০ গেজ পলিথিন	১৮ মিটার	২৫ কেজি	৭০০০.০০
অন্যান্য সামগ্রী (আলকাতরা, ৫ কেজি, গুনা তার ৩ কেজি, নাট বল্টু, সাধারন প্লাস্টিক ৩ কেজি, সুক্ষ্ম মশারী জাল)			১৫০০.০০
শ্রম মূল্য		১১ জন × ১৬৭ টাকা	১৮৩৭.০০
		মোট —	১৫৩৩৭.০০

পলিথিন বর্গমিটার ২২৮ টাকা হারে খরচ; আয়ুস্কাল ঃ ৪ বছর।

বিধানচন্দ্র কৃষি বিশ্ববিদ্যালয়ের সব্জি বিজ্ঞান বিভাগের "অল্পমূল্যের গ্রীন হাউস প্রযুক্তি" সংক্রান্ত একটি গবেষনা প্রকল্পের সংক্ষিপ্তসার ঃ

সব্জি	উন্নত/সংকর জাত	লাগানোর সময়	চারার দূরত্ব (সেমি)	ছাউনির ভিতরে ফলন (টন প্রতি বিঘায়)	বাইরে খোলা জায়গায় ফলন (টন প্রতি বিঘায়)	শতাংশ হিসাবে বেশী
ক্যাপসিকাম	ম্যানহাটন, ক্যালিফোর্নিয়া ওয়ান্ডার	সেপ্টেম্বর থেকে নভেম্বর	৬০ × ৬০	৬.৫	৩.০	১১৬%
টম্যাটো	নবীন, নিধি	ডিসেম্বরের মাঝামাঝি	৯০ × ৬০	৯.০	৩.৫	১৫৭%
ব্রকোলি	ঐশ্বর্যা	নভেম্বরের শেষ	৬০ × ৬০	২.৫	২.০	২৫%
ঢ্যাঁড়স	সগুন	ডিসেম্বরের মাঝামাঝি	৪০ × ২০	১.৫	০.৬	১৫০%

আমাদের গবেষণালব্ধ ফল থেকে এটা নিশ্চিত করে বলা যায় যে ক্যাপসিকাম, টম্যাটো ও ঢ্যাঁড়সের ফলন গাঙ্গেয় পশ্চিমবঙ্গের আবহাওয়ায় শীতকালে পলিথিন ছাউনির ভিতর ১০০ শতাংশের বেশী বাড়ানো সম্ভব। একইভাবে শসারও প্রভৃত ফলন বাড়ানো সম্ভব। আমরা মনে করি এর প্রধান কারন হলো ডিসেম্বর থেকে ফেব্রুয়ারীর মাঝ পর্যন্ত পলিথিন ছাউনির ভেতরের তাপমাত্রা অন্ততঃ ৫-৬ ডিগ্রী বেশী থাকে যা এই চারটি সব্জিরই বৃদ্ধির সহায়ক। ক্যাপসিকাম ও টম্যাটো উষ্ণতা পছন্দ করে, ঢ্যাঁড়স আর শসা আবার গরমেই ভালো হয়। এই ধরনের স্বল্পমূল্যের ছাউনির ভিতর ফলন বাড়ার আর দুটি কারন হলো (১) পরিমিত সেচ প্রদান আর (২) রোগ ও পোকার কম আক্রমণ।

গ্রীষ্মমন্ডলীয় আবহাওয়ায় ছায়া দেওয়া (shade net house) জালের ছাউনি ব্যবহার ঃ

- কম খরচার পলিহাউসের চেয়েও এর খরচ অনেক কম।
- এই ছাউনি গাছকে অতিবৃষ্টির হাত থেকে কিছুটা রক্ষা করে।
- সূর্যের তীব্র কিরণ থেকেও গাছকে স্বস্তি দেয়।
- ছাউনির ভিতরে তাপমাত্রার তীব্রতা হ্রাসপ্রাপ্ত হয়।
- গাছকে ঝোড়ো বাতাস আর শিলাবৃষ্টি থেকে বাঁচায়।
- গাছকে ভাইরাস বহনকারী কীটপতঙ্গ থেকে দূরে রাখে।
- ফলছিদ্রকারী পোকার (spam) বর্ধিত করে।
- সারা বছরই এর ভিতর কিছু না কিছু উৎপাদন করা যায়।

শুধু মশারীর (net house) জালের ব্যবহার ঃ

- অনেক কম খরচ।
- ভিতরে আবহাওয়া কিছুটা পরিমিত করে।
- দমকা বাতাস, পাখী আর শিলা বৃষ্টি থেকে ফসল রক্ষা করে।
- ভাইরাস বহনকারী পোকামাকাড় থেকে গাছকে কিছুটা দূরে রাখে।
- ফল ছিদ্রকারী পোকার আক্রমন কমায়।
- সারা বছর ব্যবহার করা চলে।

পলি হাউসের ভিতর চারা ও বীজ উৎপাদন ঃ

- ক্যাপসিকামের সংকর বীজ উৎপাদন।
- প্লাগ ট্রেতে বাণিজ্যিকভাবে সবল ও নীরোগ চারা উৎপাদন।
- পলিথিনের নীচু সুড়ুঙ্গের (poly tunnel) ভিতর বিভিন্ন শস্যের (টম্যাটো, ক্যাপসিকার, লংকা, পেঁপে ইত্যাদি) ভাইরাস মুক্ত সবল চারা উৎপাদন।
- কাটিং তৈরী করা।
- টিসু কালচারের গাছ পোক্ত করা।
- কলমের গাছ প্রতিপালন করা।

রাজ্যে সুরক্ষিত সব্জি উৎপাদন ব্যবস্থা শুরু করার জন্য জরুরী পদক্ষেপ ঃ

- সরকারী খামারে অথবা কৃষিবিজ্ঞান কেন্দ্রে অথবা কৃষি বিশ্ববিদ্যালয়ের বিভাগে ‘প্রদর্শন কেন্দ্র’ (demonstration centre) গড়ে তুলতে হবে।
- সুরক্ষিত সবজি ও অন্যান্য উৎপাদনের জন্য গুচ্ছ ভিত্তিতে (cluster basis) কৃষক নির্বাচন করে নিবিড় প্রশিক্ষণ দিতে হবে।
- গোষ্ঠীভিত্তিকভাবে উন্নত প্রযুক্তি নির্ভর চারা তৈরী ও তার বিতরণ প্রয়োজন।
- ফোঁটা সেচের ব্যবহার ও তার সাথে উদ্ভিদ খাদ্যের যোগান সুনিশ্চিত করতে হবে।
- রিমোট সেনসিং প্রযুক্তি ব্যবহার করে মাটির উর্বরাশক্তি নির্ধারণ করতে হবে।
- সমন্বিতভাবে উদ্ভিদ খাদ্য ও ফসল সুরক্ষার ব্যবস্থা করতে হবে।
- উন্নত বিপনন ব্যবস্থা গড়ে তুলতে হবে। বাজার সম্পর্কিত তথ্য ভান্ডার গড়ে তুলে বাজারের চাহিদা মোতাবেক উৎপাদন ব্যবস্থা গড়ে তুলতে হবে।
- সরকারী দপ্তর কৃষি বিশ্ববিদ্যালয়, কৃবিবিজ্ঞান কেন্দ্র ও এন.জি.ও.দের সক্রিয় অংশগ্রহনের মাধ্যমেই বাজার সম্পর্কিত তথ্য ভান্ডার গড়ে তোলা সম্ভব।
- উৎপাদন ও বিপননে সমবায় মাধ্যমকে গুরুত্ব প্রদান করা প্রয়োজন।
- দেশের ভিতরে ও বাইরে বিভিন্ন রকম বাজার তৈরী করতে হবে।

সবজি চাষের সম্ভাবনা ও সমস্যা

অধ্যাপক তপন কুমার মাইতি

আমাদের দৈনন্দিন জীবনে সবজি ভূমিকা খুবই গুরুত্বপূর্ণ। খাদ্য গুণাগুণ এগুলি শ্বেতসার, খনিজলবণ, ভিটামিন ও প্রোটিন প্রভৃতিতে ভরপুর।এছাড়া এদের ভেষজগুণও আছে।তাই পুষ্টিকর খাদ্য উপাদানের নিরাপত্তায় এদের তুলনা অপরিসীম। ভারতবর্ষের মত দেশে যেখানে জনসংখ্যার একটি উল্লেখযোগ্য অংশ দারিদ্রসীমার নীচে বাস করে এবং যাদের আর্থিক ক্ষমতা নেই দামী পুষ্টিকর খাদ্য যেমন মাছ, মাংস, ডিম, দুধ প্রভৃতি কেনার সেখানে সব্জি সহজেও স্বল্প খরচে পুষ্টিকর উপাদান যোগাতে পারে। তাছাড়া এই জনসংখ্যার একটা বড় অংশ নিরামিশাষী, সেখানে বর্তমান অবস্থার উন্নতি করতে গেলে এবং প্রতিদিন নির্দিষ্ট পরিমাণ সব্জি যোগাতে হলে চাই আরো বেশী উৎপাদন।

বিভিন্ন শাকসব্জিতে উল্লেখযোগ্য খাদ্য উপাদান ঃ

শর্করা - আলু, মিষ্টি আলু, কচু, ওল, খামালু।
প্রোটিন - বরবটী, সিম, মটরশুটি, বিন, মাশরুম।
ভিটামিন এ - গাজর, পালংশাক, পাকা কুমড়ো, মিষ্টি আলু, ব্রোকলি, টমাটো, ধনে পাতা।
ভিটামিন বি - কমপ্লেক্স, মটরশুটি, বিন, রসুন, কচু, টমাটো, সবুজ শাক।
ভিটামিন সি - কাঁচালঙ্কা, বাঁধাকপি, ফুলকপি, উচ্ছে, ওলকপি, মটরশুটি, টমাটো।
ভিটামিন ডি - লেটুস শাক, সবুজ শাকসব্জি, খামালু, বাঁধাকপি।
ভিটামিন - ইলেট্রস শাক, সবুজ শাকসব্জি, বাঁধাকপি।
ক্যলসিয়াম - বিন, বাঁধাকপি, ফুলকপি, গাজর, লেটুস শাক, মটরশুটি, পেঁয়াজ, টমাটো।
ফসফরাস - আলু, গাজর, টমাটো, শসা, ফুলকপি, লেটুস শাক।
পটাসিয়াম - মিষ্টি আলু, আলু, উচ্ছে, মুলা, বিন।
লৌহ - উচ্ছে, তরমুজ, ডাঁটাশাক, মেথিশাক, পুঁইশাক, পালং বাঁধাকপি।
আয়োডিন - ট্যাঁড়শ, শতমুলি।

পরিসংখ্যান থেকে দেখা যাচ্ছে, দেশে প্রায় ৬২.৪ লক্ষ হেক্টর জমিতে (মোট চাষযোগ্য জমির প্রায় ২.৮ শতাংশ) সবজি চাষ হয় এবং উৎপাদিত সবজির পরিমাণ প্রায় ৯৮৫.০ লক্ষ টন।বর্তমান উৎপাদন কিন্তু ক্রমবর্দ্ধমান জনসংখ্যার চাহিদার তুলনায় খুবই কম এবং এই পরিমান সবজিতে একজন লোকের প্রতিদিন কেবলমাত্র জোটে ১৭৫ গ্রাম যা পুষ্টি বিশারদদের সুপারিশের (২৮৫-৩০০ গ্রাম/প্রতিদিন) থেকে অনেক কম।

কর্মোক্ষম প্রাপ্তবয়স্কের দৈনন্দিন সুষম খাদ্য তালিকা

খাদ্য (গ্রাম)	নিরামিষাশী	আমিষাশী
তন্ডুল জাতীয়	৪০০	৪০০
ডাল জাতীয়	৫৫	৭০
শাক জাতীয়	১০০-১২৫	১০০-১২৫
মূল ও কন্দ জাতীয়	৭৫-৮৫	৭৫-৮৫
অন্যান্য সবজি	৭৫-৮৫	৭৫-৮৫

ফল	৯০	৮০
দুধ	২০০	১০০
মাছ ও মাংস	–	৩০
ডিম	–	৩০
শর্করা	৩০	৩০
চর্বি ও তৈল জাতীয়	৪০	৩৫

একজন মানুষের (দেহের ওজন ৬৫ কেজি) বিভিন্ন পুষ্টিজনিত উপাদানের দৈনিক প্রয়োজনীয়তা

পুষ্টিজনিত উপাদান	পরিমাণ	পুষ্টিজনিত উপাদান	পরিমাণ
ক্যালরি	৩০০০	ভিটামিন বি২	২.৭ মি.গ্রা.
প্রোটিন	৭০ গ্রাম	ভিটামিন সি	৭.৫ মি.গ্রা.
ক্যালসিয়াম	০.৮ গ্রাম	পটাসিয়াম	৩.০ গ্রাম
লৌহ	১২ গ্রাম	তামা	২.০ মি.গ্রা.
আয়োডিন	০.১ মি.গ্রা.	ম্যাগনেসিয়াম	০.৩৫ মি.গ্রা.
ভিটামিন এ	৫০০০ আই. ইউ.	নিকোটিনিক অ্যাসিড	১২ মি.গ্রা.

সবজির ভেষজগুণ

আলু	পোড়া
পেঁপে	কৃমি, কোষ্ঠকাঠিন্য, বদহজম
আদা	আমাশয়, কৃমি, সর্দি, কাশি, গলাব্যথা, বমিভাব
পেঁয়াজ	সর্দি, কাশি, গলাব্যথা, উচ্চ রক্তচাপ, ফোঁড়া
রসুন	কাশি, উচ্চ রক্তচাপ, ক্যান্সার প্রতিরোধী, শ্বাসকষ্ট
পুদিনা	জ্বর, মাথাধরা, বাত, মাড়িফোলা, দাঁত ব্যথা, সর্দি, অরুচি
লঙ্কা	কোমরের বাত, পায়ের ব্যথা
কুমড়ো	ফিতে কৃমি
বাঁধাকপি	দাঁতে গর্ত, চুলপড়া, চর্মরোগ, কালসিটে, পোড়া ও ছ্যাঁকা
ওল	কোষ্ঠকাঠিন্য, বাত, পেটে বায়ু, ছুলি ও দাদ, পোকার কামড়, সর্দি, কাশি
কলমি শাক	ঘাম, বসন্ত, শরীরে পারদের দোষ
গাঁদাল পাতা	আমাশয়, অজীর্ণ
কুঁদরি	আমাশয়, চর্মরোগ, মাথাধরা জিভে ঘা
থানকুনি	আমাশয়
পুইশাক	পেটে বায়ু, নিদ্রাহীনতা, রক্ত-পিত্ত দোষ
ব্রাহ্মীশাক	সর্দি, আমাশয়, স্মৃতি শক্তি
হলুদ	চর্মরোগ, কৃমি, সর্দি
কুলেখাড়া	রক্তাল্পতা, অনিদ্রা, যৌন দুর্বলতা।

পুষ্টির প্রয়োজনে খাদ্যাভাস ও রন্ধন পদ্ধতি ঃ

- সবসময় তাজা সবজি খাওয়া উচিত।
- খাদ্য তন্তুযুক্ত মূলজ সবজি গাজর, মূলা, শালগম, বিট আমাদের খাদ্য তালিকাতে যথেষ্ট পরিমাণে থাকা উচিত। কারণ খাদ্যতন্তু নিজে হজম না হলেও হজমে সাহায্য করে।
- মাঝে মাঝে কাঁচা সবজি যেমন বিট, গাজর, মূলা, পিঁয়াজ, শশা ইত্যাদি স্যালাড করে খাওয়া প্রায়োজন। কারণ স্যালাড হজমিকারক।
- সবজির পরিত্যক্ত ভোজ্য অংশে, অনেক খাদ্য উপাদান থাকে।
- মূলা, শাকগম, বিট, ওলকপি ইত্যাদির পাতা না ফেলে আলুর সাথে রান্না করে খাওয়া যেতে পারে।
- গরমজলে সবজি সেদ্ধ করে জল ফেলে দিলে অনেক পুষ্টি উপাদান বাইরে চলে যায়। সে জন্য বেশির ভাগ ক্ষেত্রেই সবজি সেদ্ধ করার পরে জল না ফেলা উচিত। সব থেকে ভালো হয় যদি সবজি জলে ধোয়ার পরে কাটা হয়।
- কচু, ওল, খামালু ইত্যাদি রান্নার সময় খোসা বেশী করে ছাড়িয়ে গরমজলে ভালো করে সেদ্ধ করার পরে জল বাইরে ফেলে দিতে হবে। কারণ এদের পুষ্টি বিরোধী উপাদানগুলি সহজেই জলে দ্রবীভূত হয়ে বাইরে বেরিয়ে যায় এবং খাওয়ার সময় গলা ধরার প্রবণতা কমে যায়।
- ভিটামিন এ -র স্থায়িত্ব তাপে অপরিবর্তনশীল থাকলেও ভিটামিন সি তাপে নষ্ট হয়ে যায়। বিশেষতঃ শাকজাতীয় সবজি খুব অল্প তাপে রান্না করতে হবে। অবশ্য ভিটামিন এ সমৃদ্ধ সবজি যেমন গাজর, কুমড়ো ইত্যাদি বেশী তাপে রান্না কার যেতে পারে।
- রান্নাতে খাওয়ার সোডার (সোডিয়াম বাইকার্বোনেট) যথেচ্ছ ব্যবহার ভিটামিনের ধ্বংসকে তরান্বিত করে। সেজন্য এই রাসায়নিক পদার্থের পরিমিত ব্যবহারের বিষয়ে সচেতন হওয়া উচিত।

বিগত শতকের শেষে আমাদের জনসংখ্যা ১০০ কোটি ছাড়িয়ে গেছে যার জন্য সবজির প্রয়োজন ছিল ১১০০ লক্ষ টন। যদি এই ক্রমবর্দ্ধমান জনবিস্ফোরণ না আটকানো যায় তবে আগামী ২০২০ সাল নাগাদ সবজির চাহিদা হবে ২২৫০ লক্ষ টন। তাই আমাদের আরো সবজি উৎপাদনের দিকে নজর দিতে হবে। বর্তমানে আমাদের সবজি উৎপাদনশীলতা বা ফলনের গড় ১৫.২ টন। বিগত দশ বৎসরে আমাদের সবজি উৎপাদনশীলতা বৃদ্ধির গড় হার ২.৬ শতাংশ যা ঐ সময়ে সারা বিশ্বের গড় বৃদ্ধির (১.৮১ শতাংশ) অনেক উপরে। সবজি উৎপাদন বাড়ানোর ক্ষেত্রে আমাদের কাছে দুটো রাস্তা খোলা আছে - (১) সবজি চাষের এলাকা বাড়ানো, যা বর্তমান পরিস্থিতিতে খুবই দুরুহ কেননা দিনে দিনে সাধারণ চাষের জায়গা কমছে, (২) প্রতি একক জমিতে উৎপাদনশীলতা বা ফলন বাড়ানো সাথে সাথে কিছু জরুরী ও সময়ভিত্তিক কর্মসূচী নেওয়া খুবই প্রয়োজন। মোট সবজি উৎপাদনের নিরিখে বিশ্বে আমাদের স্থান দ্বিতীয়, চীনের ঠিক পরেই। উৎপাদনে দ্বিতীয় হলেও গড় উৎপাদনশীলতায় আমাদের জায়গা অন্যান্য উন্নত ও উন্নয়নশীল দেশগুলির তুলনায় এমনকি চীনের থেকে অনেক নীচে। অথচ প্রাকৃতিক বৈচিত্রে সমৃদ্ধ হওয়ার আমাদের দেশে সবচেয়ে বেশী সংখ্যক সবজির চাষ হয় এবং সারা ভারত সমন্বিত সবজি গবেষণা প্রকল্পের ফলাফলে দেখা যায় কিছু কিছু সবজির ফলন সারা বিশ্বের গড় উৎপাদনশীলতার থেকে বেশী যা সবজি উৎপাদনশীলতা বৃদ্ধির ক্ষেত্রে একটি দিক নির্দেশ করে।

স্বাধীনতা পরবর্তী সময়ে সরকারীস্তরে বিভিন্ন উদ্যোগ ও কৃষিবিজ্ঞানীদের নিরলস প্রয়াসে জাতীয় স্তরে বিভিন্ন সবজির ক্ষেত্রে প্রায় ২০০ টির বেশী উন্নত জাত চিহ্নিত বা অনুমোদিত হয়েছে বিভিন্ন

এলাকায় চাষের জন্য। উল্লেখযোগ্য প্রযুক্তিগত উন্নয়ন ও হয়েছে। তাছাড়া সবজি চাষ অন্য ফসল চাষের তুলনায় লাভজনক হওয়ায় স্বাভাবিকভাবে অনেকেই এখন এই চাষে ঝুঁকছেন। তবে পরিতাপের বিষয় এই যে কেবলমাত্র ৪০-৫০ শতাংশ জমিতে এই সমস্ত জাতের চাষ হচ্ছে। প্রযুক্তি প্রয়োগের ক্ষেত্রে একই কথা প্রযোজ্য। বর্তমান পরিস্থিতিতে যেখানে দ্রুত নগরায়ন এবং চাষযোগ্য জমির সঙ্কোচন হচ্ছে, সেখানে উন্নত বীজ ও প্রযুক্তি প্রয়োগের সমন্বয়ে উৎপাদনশীলতা বাড়ানো সম্ভব। সাথে সাথে এটাও লক্ষ্য করা গেছে কিছু কিছু রাজ্য প্রাকৃতিক বৈচিত্রে সমৃদ্ধ হওয়ার বিভিন্ন সবজি অর্থকরী ফসল হিসাবে বিবেচিত হচ্ছে এবং চাষের এলাকা বেড়ে চলেছে। উল্লিখিত তথ্যসমূহ থেকে দেখা যাচ্ছে আমাদের সবজি উৎপাদন বাড়ানোর যথেষ্ট সম্ভাবনা আছে। তবে সমস্যাও অনেক। চাষীর সমস্যার বাইরে ও অনেক সমস্যা আছে।

একত্রিত করলে মোটামুটিভাবে যা দাঁড়ায়, তা হল ঃ

- অপর্যাপ্ত সাংগঠিক ব্যবস্থা,
- নির্ভরযোগ্য তথ্য বিশেষ করে সবজি চাষে জমির পরিমাণ, উৎপাদন ও ফলনের অভাব,
- উন্নতমানের বীজের অপ্রতুল সরবরাহ,
- রাসায়নিক সারের ক্রমবর্ধমান দাম ও ভারসাম্যহীন ব্যবহার,
- সেচ ব্যবস্থার অপ্রতুলতা,
- রোগ পোকা দমনে রাসায়নিক ঔষধের যথেচ্ছ ও অবৈজ্ঞানিক ব্যবহার,
- প্রযুক্তিগত তথ্য সম্প্রসারণে অসুবিধা ও অন্যান্য গ্রামীন উন্নয়ন কর্মসূচীতে,
- সবজি চাষকে যথাযথ গুরুত্ব না দেওয়া,
- আর্থিক প্রতিষ্ঠান থেকে ঋণ পাওয়ার ক্ষেত্রে অসুবিধা,
- অসংগঠিত বিপনন ও পরিবহণ ব্যবস্থা,
- সংরক্ষণ ও প্রক্রিয়াকরণ ব্যবস্থার অপ্রতুলতা,
- রপ্তানীর ক্ষেত্রে প্রতিবন্ধকতা,
- সরকারীস্তরে আর্থিকবরাদ্দে সীমাবদ্ধতা।

উল্লিখিত বিষয়গুলির মধ্যে অবশ্য কিছু আছে যা চাষীরা সচেষ্ট হলে সবজি উৎপাদশীলতা অনেকটাই বাড়ানো যাবে। যেমন —

- নামী ও বিশ্বস্থ প্রতিষ্ঠান থেকে উন্নতমানের বীজ সংগ্রহ করতে হবে।
- বীজ বোনার আগে শোধন করে নিতে হবে।
- যে সমস্ত সবজির বীজ চারা তৈরি করে লাগানো হয়, বীজ বোনার আগে বীজতলার মাটি শোধন করে নিতে হবে।
- বর্ষার সময় বীজতলা পলিহাউসে বা অন্য কোন জিনিষ দিয়ে ঢাকা দেওয়ার ব্যবস্থা করতে হবে, তবে আলোবাতাস চলাচলের ব্যবস্থা করতে হবে।
- বীজতলাতে বীজ সারিতে বুনতে হবে এবং দুটি সারির মধ্যে কিছুটা ফাঁক যেন থাকে। প্রতিটি সারিতে বীজ ঘন ঘন বোনা হলে চারা বেরোনোর পর পাতলা করে দেওয়া খুবই জরুরী।
- বীজতলাতে প্রয়োজন অনুযায়ী উদ্ভিদ খাদ্য ও জল দিতে হবে। জলের অভাব যেমন থাকবে না তেমন জল যেন না দাঁড়ায়।
- বীজতলাতে প্রয়োজনে চারা শক্ত করে নিতে হবে।

- বীজতলাতে রোগপোকা দমনে সময়োপযোগী ব্যবস্থা নিতে হবে।
- মূল জমি তৈরির সময় অনেকগুলি চাষ দিতে হবে যাতে মাটি ঝুরঝুরে হয় এবং মাটির নীচে শিকড় সহজেই চলে যেতে পারে।
- অবস্থা অনুযায়ী বীজ বা চারা জমিতে ছোট ছোট সমান প্লটে বা উঁচু প্লটে সারিতে লাগাতে হবে।
- জৈব ও অজৈব সারের মাধ্যমে সবজি চাষে সুষম উদ্ভিদ খাদ্য সরবরাহ করতে হবে। জীবাণু সার ও ব্যবহার করা যেতে পারে। তবে প্রথমে জমির মাটি পরীক্ষা করে নিতে হবে।
- এক সঙ্গে বেশী সেচ না দিয়ে মাঝে মাঝে হালকা সেচ দিলে ভালো। ড্রিপ পদ্ধতিতে সেচ দিতে পারলে জলের যথাযথ ব্যবহার হবে এবং অপচয়ও কম হবে। অনেকদিন সেচ না দিয়ে হঠাৎ করে বেশী সেচ দিলে ফসলের ক্ষতির সম্ভাবনা বেড়ে যায়।
- লতানো সবজিকে মাচাতে লাগালে ভালো ফলন পাওয়া যায় এবং রোগের প্রার্দুভাব।
- কম হয়।
- গাছের ভালো বৃদ্ধির জন্য প্রথম দিকের ফুল-ফল ছিঁড়ে ফেলা দরকার।
- প্রয়োজনভিত্তিক রাসায়নিক ঔষধ প্রয়োগ করতে হবে রোগপোকা দমনের জন্য। রাসায়নিক ঔষধ প্রয়োগের কমপক্ষে ১০-১২ দিন পরে ফসল তুলতে হবে।
- অণুখাদ্যের অভাব থাকলে ব্যবহার করতে হবে।
- জলদি ও বেশী ফলনের জন্য উদ্ভিদ বৃদ্ধি নিয়ন্ত্রক পদার্থের ব্যবহার করা যেতে পারে। তবে সাবধানতা নেওয়া খুবই জরুরী।
- সাথী ফসলের চাষ করা।
- নির্দিষ্ট পরিপক্কতাতে ফসল তোলা। যে সমস্ত সবজিতে ফল খাদ্যবস্তুতে হিসাবে ব্যবহৃত হয়। সেক্ষেত্রে মাঝে মাঝে ফল তুললে ফলন বেশী পাওয়া যায়।

MOLECULAR TECHNIQUES FOR GENETIC PURITY ANALYSIS WITH SPECIAL REFERENCE TO VEGETABLE SEED

Prof. Ashim Chowdhury & Sambit Datta and Ujjal Kumar Pati

Background :

Seed market is becoming global and its global market is growing very fast. India, the world's second-largest grain grower, produced 35.34 million quintals of seeds in 2011-12, compared with the requirement of 33.02 million quintals, according to official data. Although seed supplies have remained smooth for most of the crops, the availability of quality seeds had remained a problem until recently, the executives said. The country's seed industry is expected to grow by 53 per cent to Rs 10,700 crore by 2015 on increased demand for high-yielding varieties to ensure food security, according to industry body Assocham. Seed testing for genetic purity is one of the most important necessities for quality seed production.

Traditional genetic purity determinations have been carried out on the basis of morphological or physiological traits expressed by seeds, seedlings or mature plants. They often tend to be eronious and misleading, which causes serious problems in seed certification programmes. McDonald (1995) emphasized that seed observations and field testing are often inaccurate because environmental stress conditions during seed or seedling/plant development can mask the expression of specific morphological or physiological traits. A more reliable and stable method for seed genetic purity testing is needed to support the traditional genetic purity testing The continued release of new cultivars, particularly of F1 hybrids, by public and private breeders in the last 20 years pressed the development of faster and more reliable new technologies for genetic purity determination.

Rational :

Genetic Purity :

Genetic purity means trueness-to-type of the seed lot. It is important to assure the genetic identity which makes cultivars distinct. Genetic purity is best evaluated through a field trial in which the percentage of off-types in a seed lot is determined. Seed companies typically conduct variety trials each season to evaluate the genetic quality of contract lots; ideally, the seed lot is evaluated in comparison to the parent stock seed lot and competitors' lots of the same variety. The results of these variety trials are made available to the grower; this information is used as a tool to guide on-farm selection of the plants in the seed crop so the seed produced from that crop is true-to-type.

Genetic purity evaluation can also include screening for transgene (GMO) contamination. Corn and beets, for example, are increasingly tested for the presence of transgenes. Seed companies typically request and pay for the testing, which is conducted at independent labs. The current National Organic Program (NOP) regulations do not specifically require testing of organic seed for GMO contamination but an increasing number of certifiers are requesting testing. Avoidance is the best approach. Seed farmers should avoid planting seed crops in regions where cross contamination is likely, observe isolation distances for cross-pollinating crops, and when available, participate in regional pinning networks.

The DNA finger printing analysis is indispensible for determining the genetic purity of seed materials for which a dedicated laboratory is necessary with all the necessary facilities with backing up Technical Knowledge & proper Training. Typical equipment is necessary for this Important Laboratory along with other equipments for a typical molecular biology laboratory.

Features of PCR :

- A thermal cycling reaction undergoes in a PCR unit thereby with each cycle there is an exponential increase of the source DNA (a particular region of the DNA as chosen by the choice of the primer)
- The temperature stable taq DNA polymerase is responsible in the duplication of the DNA with the help of the oligo-nucleotide supplied in the reaction mix.
- In a very short duration of time a large amount of desired region is multiplied starting from a very small amount of DNA.
- The nature of the sequence of the primer determines the region of the DNA to be amplified and the overall result obtained.
- The discovery of the thermostable DNA polymerase enzymes provides an answer to the changes in temperature during the cycle, as the enzyme is not destroyed at the denaturation temperature of 90°C, the optimum activity being at 72°C.

Some important terms related with polymerase chain reaction :

- The PCR cycle: the reaction cycle comprises a 95°C step to denature the duplex, DNA, an annealing step of around 40°C -50°C to allow the primers to bind and a 72°C polymerization step.
- Template: almost any source that contains one or more intact target DNA molecule can, in theory, be amplified by PCR, providing appropriate primers can be designed.
- Primers: a pair of oligonucleotides of about 18-30 nt with similar g + c content will serve as PCR primers as long as they direct DNA synthesis towards one another. Primers with some degeneracy can also be used if the target DNA sequence is not completely known.
- Enzymes: thermo stable DNA polymerases (e.g; taq polymerase) are used in PCR as they survive the hot denaturation step. Some are more error-prone than others.

- Oligo-nucleotides : theseare the raw material which are attached one after the other by the taq polymerase thus synthesizing a new strand complementary to the template strand.

Steps in a PCR cycle :

1. *Denaturation* : Involves the release of the double stranded DNA into two single strands. This occurs typically at a temperature of 94°c. Each of the two single strands behaves as a template DNA.
2. *Annealing* : this is a temperature set by the character of the primer used, upon its tm. The step involves the attachment of the primer to each of the two single stranded DNA at complementary sites.
3. *Extension* : This step involves the synthesis of a new strand of DNA based on the complementary bases of the genome template. The synthesis involves the Taq polymerase enzyme which joins new oligo-nucleotides one after the other.
4. These three fundamental steps are repeated over a varying period of time to bring about differential exponential growth in volume of the DNA. The amplified fragments of DNA are known as amplicons.

Following is the depiction of :

Typical PCR cycle :

Initial DNA denaturation (typically 92°C-94°C)

1. Cycle DNA denaturation (94°C for a min)
2. Annealing (depends on the tm of the primer, 1-2 mins)
3. Extension (typically at 72°C for 1-2 mins)

Loop : no. of cycles of the above three steps
Final extension (typically at 72°C for 5 – 10 mins)
Completion of PCR cycle (typically 2 to 3 hrs)

The continued release of new cultivars, particularly of f_1 hybrids, by public and private breeders in the last 20 years pressed the development of faster and more reliable new technologies for genetic purity determination. The use of DNA based markers for genetic purity testing is fast emerging to be a convenient, reliable and cost effective method DNA based markers are efficient because DNA markers segregate as single gene and are unaffected by environmental factors. (**Rahman et 2006**) there are various types of genetic markers, and they have varied use in various field of plant breeding, varietal differentiation or seed testing procedures.

Types of molecular markers :

(a) RFLP (restriction fragment length polymorphism).
(b) Sequence-Tagged Sites (STS).
(c) Expressed Sequence Tag markers (EST).
(d) Single Strand Conformation Polymorphism (SSCP).
(e) Microsatellites and Minisatellites.
(f) Minisatellite and microsatellite sequences converted into PCR-based markers.

(g) Sequence-tagged microsatellite site markers (STMS).
(h) Direct Amplification of Minisatellite DNA markers (DAMD-PCR).
(v) Inter Simple Sequence Repeat markers (ISSR).
(j) Transposable elements.
(k) Repeat Complementary primers.

Arbitrary sequence markers :

(a) Randomly Amplified Polymorphic DNA markers (RAPD).
(b) DNA Amplification Fingerprinting (DAF).
(c) Cleaved Amplified Polymorphic Sequences (CAPS).
(d) Amplified Fragment Length Polymorphism (AFLP).

Sequence characterized amplified regions for amplification of specific band (SCAR) :

It is the amplification of a particular locus. These are similar to STS markers in construction and application. The presence or absence of the band indicates variation in sequence. These are better reproducible than RAPDs. SCARs are usually dominant markers, however, some of them can be converted into co-dominant markers by digesting them with tetra cutting restriction enzymes and polymorphism can be deduced by either denaturing gel electrophoresis or SSCP. Compared to arbitrary primers, SCARs exhibit several advantages in mapping studies (co-dominant SCARs are informative for genetic mapping than dominant RAPDs), map-based cloning as they can be used to screen pooled genomic libraries by PCR, physical mapping, locus specificity, etc. SCARs also allow comparative mapping or homology studies among related species, thus making it an extremely adaptable concept in the near future.

Extraction of Genomic DNA :

Total genomic DNA of a seed is the starting material of our work. The extraction and purification of this genomic DNA ensures the quality of all downstream works, especially amplification of this DNA in a thermal cycler unit. The better is the extraction procedure, the good the quality of the DNA. Hence care should be taken at each and every step in this whole operation.

Requirements :

CHEMICALS :

SUITABLE BUFFER (EX, TRIS-HCl)
DETERGENT FOR CELL LYSIS (SDS)
PHENOL (Tris equilibriated)
CHLOROFORM
ISO AMYL-ALCOHOL
SODIUM/AMONIUM ACETATE
ISO/PROPANOL
STERILE WATER

***TECHWARE* :**

MOTOR PESTLE/TISSUE HOMOGENIZER
REFRIGERATED CENTRIFUGE
BENCTOP CENTRIFUGE
MICRO PIPETES
MICROTIPS, MICROTUBES
-20C REFRIGERATION UNIT

Method of DNA Extraction :

1. Suitable amounts of tissue are to be crushed in appropriate amounts of extraction bufferunder cold conditions.
2. The extractant is incubated at 65C for 20 to 30 mins for effective cell lysis.
3. The slurry is then centrifuged at 12,000 rpm for 10 mins at 4C. The centrifugation removes the tissue debris and the clear supernatant is transferred to a new tube.
4. The supernatant is removed carefully to a fresh tube. An equal volume of Phenol: chloroform: isoamyl alcohol 25:24:1 is added and the tube is inverted thoroughly to mix.
5. Centrifugation is performed at 12,000 rpm at 4C for 10 mins. The upper aqueous layer is carefully removed to a new tube.
6. The steps 4 and 5 are repeated at least twice.
7. The final aqueous phase from the last chloroform phenol treatment is taken in a fresh tube. A requisite amount of 5M sodium/ammonium acetate is added to the tube and incubates the mix on ice for 30 mins.
8. Add ice cold isopropanol to the solution and centrifuge at 12,000 rpm for 20 mins to facilitate precipitation of DNA.
9. Discard the supernatant carefully without losing the DNA pellet. Wash the DNA pellet with 70% ethanol twice. Air dry the pellet dissolve in tris buffer and store at -20C for future use.
10. Check the quality of the DNA solution by loading a part of it on a 0.8% agarose gel.

PCR Assays for Random Amplified Polymorphic DNA :

Polymerase chain reaction or PCR as is commonly called refers to a process where a polymerization reaction chain of molecules is performed by cyclical temperature ups and downs with the aid of a thermostable enzyme to produce large quantities of the end product. PCR employs a DNA replication process in vitro to amplify large quantities of DNA from a very minute quantity of starting material. In DNA replication a template DNA strand is used to synthesize a complimentary copy of its own, by using dNTP's (raw material), a DNA polymerase enzyme and a short strand of a few bases of purine and pyrimidines, known as the primer. In vivo this reaction takes place inside a cell with the help of a series of enzymes. However in vitro, the same process is performed with the aid of a thermostable enzyme known as the TAQ Polymerase (first of its kind was isolated from a thermophilic bacteria *Thermus aquiticus*), and cyclically maintained heat reversals. The entire in vitro process is carried out inside a thermocycler or a PCR unit which cycles alternate high and low temperatures. Typical a double helix DNA molecule under goes a strand separation at a temperature of 92°C-94°C. Then comes the step where a short *in vitro* synthesized oligo sequence anneals to its complementary sequence of the denatured DNA. The temperature of this step depends typically upon the nature of the base composition of the short oligo, salt concentration and length of the oligo. After this the TAQ polymerase binds to the primer/DNA duplex and carries out an extension step using supplied dNTP's in the reaction mixture. The temperature for this reaction is carried out at 72°C. These three steps are repeated over and over again to get a large repertoire of DNA molecules from initial small amount of mother stock. Therefore the basic steps of a polymerase chain reaction are a DENATURATION step, an ANNEALING step, and an EXTENSION step. However this reaction cannot be never ending as after a number of cycles the activity of the TAQ polymerase ceases. This in turn depends on the quality of the TAQ used.

Chemicals required :

- TAQ polymerase
- Genomic DNA
- dNTPs (ATP, GTP, CTP, and TTP)
- PCR reaction buffer (Commercially available)
- MgCl2 (optional, as commercially available PCR buffers often are pre added with this).
- Sterile deionized water
- A thermocycler or a PCR reaction unit as is commonly called.

Procedure :

PCR reaction is carried out in 0.2 ml PCR tubes specially designed for carrying out the reaction under high temperatures in a thermocyclers. The net reaction mixture in our case is 25 il. In a RAPD reaction, the primers are so designed that they have a moderately high GC content, and will anneal at random sites along the genomic DNA according to their complimentarily. The amplification thus produced when visualized on an agarose gel will show a number of bands of different sizes and will vary with different genotypes using the same primer.

The reaction mixture contains the following ingredients in the mentioned proportions:

TAQ buffer	4.0 µl (Commercially available)
dNTP	3.0 µl (Commercially available. From stock mix)
TAQ polymerase	0.2 µl
Primer	1.0 µl
Genomic DNA	2.0 µl
Sterile water 1	4.8 µl

The thermocycler was programmed in the following way to carry out the reaction:

T = 94°C	00:02:00
T = 92°C	00:00:45
T = 32°C	00:01:00
T = 72°C	00:02:00
GOTO 2	REP 39
T = 72°C	00:10:00
SOUND 05	

Agarose Gel Electrophoresis :

This is a highly flexible method to that provides information on the size of the DNA molecules and under certain conditions can be used to differentiate between different sequences of the same size. For DNA electrophoresis the most common substances used are **Agarose and Polyacrylamide**. Agarose gels are more robust and easy to prepare than there polyacrylamide counterparts. The strength of Agarose gels determines the molecular weight (MW) of the fragment of DNA to be separated. Conventional Agarose gels can separate DNA fragments from a size of 200 bp to 50,000 bp, which is more than adequate for PCR based systems. The typical concentrations of Agarose needed for the separation of fragments are given in the table below :

Concentration of Agarose (Percentage w/v)	Molecular weight range
0.6%	1000 – 20,000 bp long PCR
1%	500 – 5000 bp
2%	100 – 2000 bp
3%	10 – 500 bp

Two buffer systems are involved with Agarose gel electrophoresis of DNA. **Tris Acetic acid EDTA (TAE)** buffer is more commonly used as it facilitates recovery of DNA from gel. However it has a lower buffering capacity and recirculation of buffer may be needed after long electrophoresis runs. **Tris Borate EDTA (TBE)** is preferred for small DNA molecules and longer electrophoretic runs. Independent of the buffer selected, attention is to be paid to the depth of the buffer. Insufficient amount of buffer would dry up the gel during running, whereas excessive buffer would hinder the flow of the current through the Agarose support, promote heating and hinder mobility of the DNA molecule. Preferably 3 to 5 mm of buffer should cover the gel during its running. Electrophoresis is performed with a voltage of 1 to 5 Volts/cm (where cm is the distance between the electrodes of the tank.

Chemicals required :

- Tris base
- EDTA
- Boric acid

- Bromophenol blue
- Xylene cyanol
- Glycerol
- Deionized sterile distilled water
- DNA molecular weight marker

Apparatus required :

- Submarine electrophoresis apparatus
- Acrylic comb
- Electrophoresis power supply
- A plane clean work bench
- Oil Leveler

Procedure :

1. Weigh required amount of agarose (determined according to the percentage of gel desired) in TAE or TBE buffer (1X)
2. Heat the solution until the agarose dissolves and a clear solution is obtained.
3. Cool the solution till the temperature is bearable on bare hands. Add ethidium bromide to this solution. This stain allows to visualize the DNA band after the agarose run.
4. Pour the gel in the caster tray with the comb inserted. Allow the gel to solidify.
5. Gently remove the comb and place the gel tray in the running tank.
6. Submerge the gel with the running buffer. Load the wells with the DNA.
7. Connect to a power supply and apply constant current. Run the gels for 1-3 hours depending upon necessity.
8. Disconnect power supply take out the gel tray. Drain excess buffer and place the gel in a UV cabinet of a gel documentation unit.
9. Visualize the bands and take a photograph of the gel with future reference.

References :

POTENTIALITY AND PROSPECT OF VEGETABLE CROPS - AN OVERVIEW

P. K. Chattopadhyay

India, a vast country bestowed with varied soil and agroclimatic conditions is able to grow wide range of vegetable crops. Vegetables are important due to their great demand both domestic and foreign market.

Vegetables are known as protective foods as the phytochemicals in vegetables protect the human body from cancers and cardiovascular diseases. Vegetables add variety, colour and texture to our daily diet. Vegetables are generally low in protein and fats and mostly with high moisture and low dry matter content while they are rich in Vitamin-C, Vitamin-A, folic acid, dietary fibre and minerals. The vast potential of vegetable crops is yet to be fully exploited.

Vegetables for nutritional security :

The basic minimum requirement of vegetable for an adult is 300 g per caput per day. We consume much below the requirement. Orange yellow pigment in vegetables known as carotenoids are converted into Vitamin-A in the body and thus carotenoids are precursor of Vitamin-A. Vitamin-A is not present as retinol in vegetables. Leafy vegetables, spinach, cabbage, broccoli, asparagus, carrot, tomato, sweet potato, musk melon and pumpkin are good source of carotene. Vitamin-C rich (ascorbic acid) vegetables are: tomato, cauliflower, cabbage, Knolkhol, bittergourd, pepper, broccoli, turnip, drumstick leaves, amaranth. Vegetables are major sources of folate (folic acid) and these are : spinach, okra, Chinese cabbage, cowpea, asparagus, green and vegetable soyabean. Natural Vitamin E (D--tocopherol). It is one of the most efficient chain breaking antioxidant and primary defender against lipid per oxidation. This vitamin is found in parsley, spinach, broccoli and asparagus. Minerals mainly calcium is available in green beans and green leafy vegetables. Broccoli is a good source of Ca and Mg. Vegetables are rich source of dietary fibre. The indigestible carbohydrates present in the food are commonly known as dietary fibres. Dietary fibres are associated with reduced incidence of coronary heart diseases. Low fibre diet is associated with colon cancer. Vegetables contain several compounds that are valuable antioxidant (ß-carotene, lycopene, cryptoxanthin, leutin, zea xanthin). Important vegetables are : asparagus, bitter gourd, broccoli, cabbage, carrot, cauliflower, cucumber, lettuce, green pepper, spinach, ripe tomato. Flavonoids (flavones, flavonols, flavanones, isoflavanones, flavan-3-ols, anthocyanins, calcechins, biflavans and isoflavonoids) are a large family of low molecular weight polyphenolic compounds and have antioxidant activity. Flavonole rich vegetables are : lettuce, onion, red pepper, broad bean, French bean. There are many underutilized vegetables which have high potentiality (agathi, drumstick, water spinach, Indian spinach, chenopod, gogu). These underutilized vegetables including many cucurbits (kakona, kheksa, snake gourd, sponge gourd, ridge gourd, ivy gourd, chowchow) are also potential. It is suggested to drink a glass of vegetable juice at breakfast. Put a slice of tomato on toast or other vegetables. Take salads during lunch with plenty of carrots, red cabbage and other roughage. Eat vegetable soup of leafy vegetables. Add a side cooked vegetables. Eat at least 2 vegetables during dinner and have a salad. Vegetables are thus protective and is important for nutritional security.

Vegetables as a high value crop :

In the recent times there have been dramatic changes in the patterns of production, consumption and trade in Indian Agriculture. The most marked change is the shift in production and consumption from food grains to high value agricultural specially horticultural commodities such as fruits, vegetables, flowers, spices, processed products etc. High value horticulture is a potential area for income growth in rural and urban areas even with small holders agriculture.

High value agriculture is a major contributor for building economy of many states. Fruits and vegetables contribute more than 30 per cent to value of output from agriculture in Himachal Pradesh, Odisha, West Bengal, Jammu & Kashmir, Bihar and North-East states.

Growth of vegetables at a glance :

Trend in growth rate in value of output from vegetables has been found to be variable. Share of vegetables is higher and in case of rural areas vegetables are third important food item after cereals, milk and milk products.

The area under fruit and vegetables is about 8 percent of available land for agriculture (total cropped area). The area has increased from about 8.5 million ha to 14.7 million ha while production has increased from about 87 million tons to nearly 210 million tonnes. Several researchers have examined issues related to diversification of agriculture and progress and potential of horticulture industry in the country.

Production growth of vegetables is slightly better at present (6.4%). The area under vegetable has increased from 5.17 million ha to over 8 million ha while production has increased from 62.7 million tons to over 131 million tons. The average yield per ha has increased from 12.2 million tons to 16.4 million tons. These figures amply proves the potential of horticulture in the country.

Vegetable production scenario :

The major vegetables produced mainly for domestic consumption in India are potato, onion, tomato, brinjal, tapioca, cabbage, cauliflower, okra and peas. Potato is most widely grown vegetable crop in India with a share of 25.3% in total vegetable production followed by onion (10.2%), tomato (8.6%) and brinjal (7.6%).

Leading producers of vegetables in India are as follows : Potato (West Bengal-WB, Uttar Pradesh-UP, Bihar, Punjab, Gujarat, Madhya Pradesh-MP and Assam); Onion (Maharashtra, Karnataka, Gujarat, Bihar, M.P., Rajasthan, Andhra Pradesh-A.P., Tamil Nadu-T.N., Haryana, UP, Odisha, W.B., Jharkhand); Tomato

(Karnataka, A.P., Odisha, Bihar, W.B., Maharashtra, Gujarat, Chattisgarh, M.P., Jharkhand, T.N, Himachal Pradesh-HP, Haryana, UP); Brinjal (W.B., Odisha, Bihar, Gujarat, A.P., Maharashtra, Chattisgarh, Karnataka, MP); Okra (WB, Bihar, Odisha, A.P., Gujarat, Jharkhand, Chattisgarh, Maharashtra, UP, Haryana); Peas (U.P., MP, Jharkhand, H.P., WB, Punjab, Chattisgarh,Uttarakhand, Haryana, Bihar, J & K); Cauliflower (WB, Bihar, Odisha, Haryana, Jharkhand, Gujarat, Chattisgarh, M.P., Punjab, U.P., Delhi); Cabbage (WB, Odisha, Bihar, Gujarat, Jharkhand, Chattisgarh, Haryana, Karnataka, M.P., H.P., A.P., T.N.); Tapioca (Kerala, Karnataka, A.P.); Sweet potato (Odisha, U.P., W.B., Karnataka, Assam, M.P., Chattisgarh).

[*Source* : *Indian Horticulture Database, NHB, Ministry of Agriculture, Govt. of India*]

Apart from pure crops, vegetable crops can suitably be grown in many other ways. Variety, period of availability and major production areas of vegetables in West Bengal are presented below :

Variety, Period of Availability and Major Production Areas in West Bengal.

Vegetables	**Vegetable Variety**	**Period of Availability**	**Major Production Areas**
Tomato	Pusa Ruby, Pathar Kuchi S-12, Roma Super Hybrids: Rupali, Baisali, Nobin	January to March	24-Pgs North, 24-Pgs South Nadia
Cabbage	Golden acre (early), Pride of India (Early), Pusa drum head (Late) Hybrid : Green Express	September to March	North & South 24-Pgs., Naida, Murshidabad Hoogly, Burdwan
Cauli-flower	Jawahar Moti (early), Pusa Depali (Mid); Dania (Late) Pusa snowball (Late)	November to March	North & South 24-Pgs., Naida, Murshidabad Hoogly, Burdwan
Peas	Arkel, Meteor, Bonevalle Johar Motor	January to March	Naida, Hoogly, 24 Pgs, North
Brinjal	Pusa Purple Long, Pusa Kranti, Mukta Keshi	Throught the Year	Hooghly, Burdwan
Onion	Nasik Red, Pusa Red, Red Globe	March to April	Hooghly, Burdwan
Cucurbits	Ridge Gourd - Pusa Nasdar, Pumpkin : Arka Surajmukhi, Arka Chandan	January to July	North & South 24-Pgs., Nadia, Murshidabad, Hooghly, Burdwan
Ladys-finger	Pusa Swani, Parbani Kranti	April to September	North & South 24-Pgs., Nadia, Murshidabad, Hooghly, Burdwan

Radish	Pusa Himani, Red Bombai, Pusa Chetki	October to February	North & South 24-Pgs., Nadia, Murshidabad, Hooghly, Burdwan
Carrot	Pusa Keshwar, Nantes	October to February	North & South 24-Pgs., Nadia, Murshidabad, Hooghly, Burdwan
Water-melon	Sugar Baby, Arka manik	March to May	North & South 24 Pgs., Midnapore East
Beans	Pusa Parbati, Contender	January to March	North & South 24 Pgs.
Bitter Gourd	Pusa-do-Mousami, Local Small	April to September	North & South 24 Pgs., Nadia, Murshidabad, Hooghly, Burdwan

Source : Department of Food Processing Industries and Horticulture, Govt. of West Bengal

Constraints :

Scope, Potential and approach :

The following aspects need special attention. Vegetable growing needs special skill, knowledge and labour throughout the growing season. To achieve higher productivity and increased production a comprehensive knowledge of the various aspects of vegetable production technology, environmental stresses, constraint, seedling raising, pre and post harvest technologies, marketing etc. is very important. Our weak database on area, production and productivity is one of the major constraints for the fullest exploitation of the potential in our country.

Leaf and soil analysis are two important aspects that helps in diagnosis and prediction of fertilizer requirement. Vegetable growers are to be helped in assessing nutrient status of soil and plants for identifying fertilizer needs. Micronutrients also play a crucial role in vegetable production. Integrated nutrient management need special attention.

Integrated pest and disease management is the most important aspect of modern crop management. This helps to keep the environment pollution free and balanced is maintained in the agro ecosystem. Moreover, the produce will be free from toxicity. The use of non degradable chemicals in controlling pests and diseases leaves residues in various living systems as well as in the produce. A thorough knowledge is essential on the pest and disease occurance (Disease/pest forecasting) to develop location specific management strategy. Bio-control is gaining importance as it is environment friendly and ecologically safe.

Biotechnology is a powerful tool and can be employed in several ways. Organic vegetables have high demand. This prospective area needs to be explored with proper back up of all sectors involved in this venture.

Low cost cool chamber may be introduced for short term storage of vegetable.

The intensive research and development and the entry of corporate sector in vegetable seed business have contributed a lot to the vegetable industry in India. The increasing trend of vegetable production shows an ample scope and potential of vegetable in India. Increasing productivity through hybrids, breeding for higher yield and resistance to diseases and insect-pest attack, making availability of disease free breeding and planting materials and seed plot technique in potato and producing seed of over 120 varieties of the open pollinated, high yielding vegetables are major achievements in the vegetable research and development. The benefits are to be made available to the farmer.

Marginal and small farmers are predominating vegetable cultivation in India. The foundation and certified seeds are produced by public funded seed corporation and private seed companies. Hybrid seed is easily available due to development of self incompatible, gynoecious and male sterile lines in different vegetables.

Mulching, drip, sprinkler systems of irrigation and green house technology need to be encouraged for more water use efficiency to achieve higher productivity. Water harvesting techniques need to be promoted.

A major thrust need to be given on development of both irrigated and rainfed production system to augment food supply, exports and generate employment opportunities for rural masses. Precision farming and good agricultural practices (GAPs) are to be encouraged.

India export onion, potato, beans, peas, green chilli, broccoli, asparagus, mushroom, capsicum, lettuce etc. the world over. In cauliflower, onion and cabbage production are quite appreciable. Similarly, tomato cultivation is now feasible throughout the year due to availability of varieties both for Summer and Winter season. The optimum post harvest technology in potato, onion, tomato, peas and other valuable vegetable is an added advantage for vegetable growers. Value added products have markets all over the world.

Use of plastics has got wider acceptability the world over. The lining of canal, drip irrigation, use of pipes for water conveyance, pond lining, packaging of fruit, vegetable; protected crop cultivation, mulching through plastic, storage structure and soil solarisation are main applications of plastic.

Plastics for packaging is more cost effective than the conventionally used packaging material. About 1 kg of low density polyethylene can carry 150 kg of the produce in one cycle. In lining operation, 1 kg of 400 gauge LDPE saves about 60,00,000 litre of water by checking the seepage. Plastics crates for transporting bulk of the products ensures safer environmental protection, preventing forests at large scale. Use of plastic films for glazing green houses reduces the cost of green house construction to almost 10% of the cost towards using glass for the same. There is still a large untapped potential area requiring plastics. Smart, biogradable plastics with biosensors stand to revolutionize the packaging, handling and storage sectors. India therefore, must adopt the plasticulture techniques like China, South Korea, Taiwan, Japan, Thailand, Israel, the Netherlands etc.

Agri-Export Zones (AEZ) have been identified by the potential products and the geographical regions in which they are grown, adopt an end-to-end approach of integrating the complete process right from the stage of production, then processing, packaging and finally leading to export. These zones add value to basic agricultural produce by improving the product quality. In West Bengal, vegetables Agri Export Zone covers the districts of North 24 Parganas, Nadia and Murshidabad and for potato the districts are: Howrah, Hooghly, Burdwan and West Midnapore.

The National Agriculture Policy for the 200 million Indian farmers is necessary to actualize the vast untapped potential of Indian Agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate growth of agro-business, create employment opportunities in rural areas, secure a fair living standards of farmer and their families, stop migration to urban areas and face the challenges of economic liberalization and globalization. The policy also envisages a wide usage of conservation of biodiversity which will include conservation of bio-resources, especially of plant species going to be extinct, through scientific preservation in gene banks and conservation in their natural habitat through biodiversity parks.

Indian farmers need to meet the challenges of world competitive marked and WTO would provide an opportunity to compete at the global level. The quality of the produce will improve with the adoption of new techniques and diversification including value addition would reduce post harvest losses. Thus WTO may give an impetus for adoption of high tech which will help to earn more and more foreign exchange.

The farmers need to grow the crop as per demand or market potential to be competitive at national and international level. They should have a market network and send only required quantity of the produce. Therefore, safeguarding the interest of the farmers, organized farmers' association will remove undue interference of the middlemen. Thus these organizations would regulate market accordingly and earn whole profit to their farmer members only.

All vegetables may be grown with ease since our country is blessed by Weather God Generously. Let us therefore be conscious, about the intake of real protective vegetables to keep us fresh and healthy. With higher productivity and quality production India can also add a substantial amount of foreign exchange through export.

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